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CONTENTS.

RAILROAD CURVES.

The following tables show the distance from the point of intersection of the tangent lines to the beginning of a one degree curve, the angle of deflection (=angle at centre) being known.

In the columns, under the head of degrees and opposite the minutes, are given the distances in feet from the intersection of tangents to the beginning of one degree curve.

To ascertain the distance for any given degree of curve, divide the distance given in the tables for a One degree curve, by the degrees of the required curve, and you have the distance from the point of intersection to the beginning or end of curve.

EXAMPLE:

Required the distance from the point of intersection of tangents to the beginning of a Two degrees curve, the angle of deflection being 25°.

In the tables under 25°, and opposite 0′, find 1270.28 which divided by the degrees of the curve (2°) give 635.14 feet, the required distance.

In staking the centre line for a railroad or a canal, stakes should be driven down to near the surface of the ground, at the intersection of the tangents, and at the different stations; and nails set in indicating the centre point. These stakes serve also for leveling purposes and are useful in detecting errors while the work is being relevelled and staked out.

The beginning and end of curves should have reference stakes set at right angle to the centre line, similarly driven and marked, and at such convenient distance from the centre as will insure them from being displaced in making excavations and embankments; and at all the above named points another stake for numbering, &c., should be firmly driven adjacent to them.

The radius of a One degree curve is 5730 feet. The circle being divided into 360 parts of one degree (equal angle of deflection) give 360 chords of one foot in length at the circumference, and also a radius of 57.3 ft. thus:

$$\frac{360}{3.1416} = \frac{114.6}{2} = 57.3$$

The chord of One foot in length for 1 degree = 57.3 ft. Radius.

" 10 feet " " " = 573.0 "

" 100 " " " " = 5730.0 "

Or the radius may be calculated by natural sines, thus:

sin. 1°: 100 ft. chord : : sin. 89° 30′ : 5730 ft. radius.

To determine the degree of curvature, having the radius given, divide the radius of a One degree curve, 5730, by the radius of the given curve.

EXAMPLE:

Required the degree of a curve having a radius of 1000 feet:

$$\frac{5730}{1000} = 5.73° = 5° 43′ 48″$$

To determine the length of the curve having the angle of deflection given; divide the angle of deflection (=angle at centre) by the degrees of the curve, and you have the required length of the curve. If there are degrees and minutes in the angle of deflection, the minutes should be converted into decimals.

EXAMPLE:

The angle of deflection being 20° 49′, $\frac{49}{60} = 0.816$. Then 20.816 is the distance for a One degree curve; if for a 2 degrees curve, divide this result by 2; for a 3 degrees curve, divide by three, and so on.

The angle of deflection being given, the following results are readily determined:

Angle of deflection	Degree of curve	Deflection per 100 feet.	Radius of curve	Dist. from intersec. to beginning of curve.	Length of curve.
20° 49′	1°	0° 30′	5730.	1052.49	2081.6
20° 49′	2°	1° 00′	2865.	526.24	1040.8
20° 49′	3°	1° 30′	1910.	350.83	693.8
20° 49′	4°	2° 00′	1432.5	263.12	520.4
20° 49′	5°	2° 30′	1146.	210.50	416.3

To ascertain the radius of a curve, having the angle of deflection, and the distance from intersection to beginning of curve given. Find the distance for the angle of deflection in the tables, which divided by 5730. gives the natural tangent of half the angle.

Then divide the distance from intersection to beginning of curve by the natural tangent of half the angle, and you have the radius.

EXAMPLE:

Required the Radius of a curve, the angle of deflection being 20°, and the distance from intersection of tangents to beginning of curve 225 feet.

Under 20° and opposite 0′ in the tables, find 1010.37, which divided by 5730 feet gives the natural tangent 0.17633. Then 225 ft. divided by 0.17633 gives the radius 1276 feet.

FIELD NOTES FOR A ONE DEGREE CURVE.

Bearing of 1st tangent . . . . . N. 20° W.
" 2d. " . . . . . N. 40° W.
Angle of deflection by needle . . . . . 20°
" " " graduated card . . . 20°

The angles measured with the card are the most reliable; but the angles by the needle although it often indicates a slight differ-

ence, serves as a check to greater errors which may arise in reading the degrees on the graduated limb of the instrument.

* Station No. 506.2000 Intersection of tangents.

— 10.1037 from intersection to beginning of curve.

* Station No. 496.0963 point at which curve commences.

\+ 20.0000 length of curve.

* Station No. 516.0963 point at which curve terminates.

DEFLECTION FROM TANGENTS.

Stations.	Length of chords in feet.	Deflection from tangent.	REMARKS.
496.096	" "	" "	* Beginning of curve.
497.	90.37	0° 27	1° to left. (Tang. due N.)
498.	100.00	0° 57	
499.	100.00	1° 27	
500.	100.00	1° 57	
501.	100.00	2° 27	
502.	100.00	2° 57	* Change point.
503.	100.00	3° 27	
504.	100.00	3° 57	
505.	100.00	4° 27	
506.	100.00	4° 57	
507.	100.00	5° 27	
508.	100.00	5° 57	
509.	100.00	6° 27	* Change point.
510.	100.00	6° 57	
511.	100.00	7° 27	
512.	100.00	7° 57	
513.	100.00	8° 27	
514.	100.00	8° 57	
515.	100.00	9° 27	
516.	100.00	9° 57	
516.0963	9.63	10° 00	* End of curve. (Tangent N. 20° W.)

FIELD NOTES FOR A TWO DEGREES CURVE.

Bearing of 1st tangent ..... N 10° W.
" 2d " ..... N 30° W.
Angle of deflection by needle..... .... 20°
" " by graduated card..... 20°
Station.... 506.200 intersection of tangents.
— 5.052 from do. to beginning of curve.

Station.... 501.148 point at which the curve commences.
+ 10.000 length of the curve.

Station.... 511.148 point at which the curve terminates.

DEFLECTION FROM TANGENTS.

Stations.	Length of chords in feet.	Deflection from tangent.	REMARKS.
501.148	" "	0° 00′	* Beginning of curve 2° to left.
502.	85.20	0° 51	(Tangent N 10° W.)
503.	100.00	1° 51	
504.	100.00	2° 51	
505.	100.00	3° 51	
506.	100.00	4° 51	
507.	100.00	5° 51	* Change point.
508.	100.00	6° 51	
509.	100.00	7° 51	
510.	100.00	8° 51	
511.	100.00	9° 51	
511.148	14.80	10° 00	* End of curve. (Tangent N 30° W.)

In curves of great length, the instrument should be moved forward in about every five or six hundred feet to insure accuracy, and often to avoid obstruction in line. The mode of proceeding in such cases may be illustrated with the deflections of the 2° curve.

The instrument in the first place is set at station 501.148 and the deflection from tangent to station 507 is 5° 51′. Now change the position of the instrument to station 507, and bring the cross hairs to bear on the staff at station 501.148; after clamping the instrument turn with the vernier as a test

for station 502,	0°51′	
for " 503,	1°51′	
for " 504,	2°51′	
for " 505,	3°51′	
and for the tangential station 507,	5°51′	* Ch. pt.

If the stakes are found to be correct, continue the setting of the remaining stakes to end of curve, and deflect the degrees from the beginning of curve given in the field notes opposite the respective stations.

When an odd number of minutes are to be turned off at the commencement and for each successive station, the inconvenience may be obviated by setting the vernier the number of minutes for the required chord in an opposite direction from that in which you would turn for the stations in the curve; or so that the instrument when set in line with the tangent and clamped, the nonius instead of reading 0, will indicate the number of degrees or minutes which would be deflected to strike in line with the first stake to be set in the curve. Then the remainder of the stations will be free from the odd minutes which would otherwise be turned off for each successive station.

When the instrument is moved forward to another station, the same mode may be adopted with reference to setting the nonius preparatory to bringing the cross hairs to bear on the staff at the beginning of curve.

By determining the tangents at the various points in the curve over which the instrument may be set, the staking of the curve may be prosecuted with less liability to error.

At the end of curve the instrument should be set over the stake to ascertain if the tangent produced from deflection corresponds with the course and direction of the tangential line.

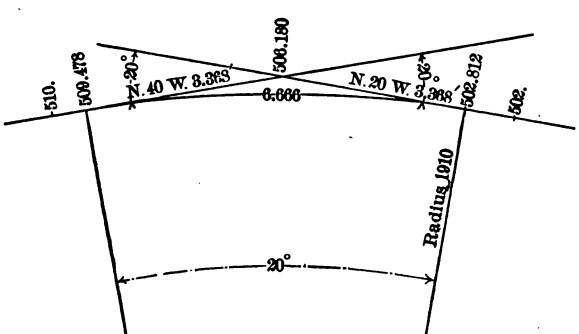
FIELD NOTES AND METHOD OF STAKING A 3 ° CURVE.

Bearing of 1st tangent, N. 20° W.
" 2d " N. 40° W.
Angle of deflection by needle 20°.
" " by graduated card 20°.

* Station . . 506.180 intersection of tangents.
— 3.368 from do. do. to beginning of curve.

* Station . . 502.812 point at which the curve commences.
+ 6.666 length of curve.

* Station . . 509.478 point at which the curve terminates.



The notes are put down as represented in this diagram, and numbered from right to left when curving to the left, and from left to right when curving to the right.

FIELD NOTES.

No. of Station	Length of chords.	Course of tangents and chords.	Deflect'n from tangent.	REMARKS.
502.812	" "	N 20° W	0° 0′	* B. C. 3° to left.
503.	18.8	20° 17′	0° 17′	
504.	100	22. 04	1. 47	
505.	100	25. 04	3. 17	* Change point.
506.	100	28. 04	4. 47	
507.	100	31. 04	6. 17	
508.	100	34. 04	7. 47	
509.	100	37. 04	9. 17	
509.478	47.8	29. 04	10. 00	* E. C.
510.	52.2	N 40° 00 W		

The number at which the curve ends should be given to the chainman before proceeding to measurement, so that the proper signal may be made by him on arriving at the station next preceding the termination of the curve.

Then set the instrument over the point of curve at station 502.812 and deflect from the tangent line for station 503, 0° 17′
" " 504, 1° 47′
" " 505, 3° 17′

and so on to the end of curve as per column of deflection, unless the instrument is moved forward. If it is necessary to move the instrument, then set it over another stake in the curve, bring the cross hairs to bear on the staff at the beginning of curve and clamp the instrument; then turn off for the tangent at the station selected, the same number of degrees originally turned from tangent at beginning of curve in setting the stake, and 1° 30′ additional for each successive station of 100 feet as you advance; the angles should correspond with those given in the column of deflections set opposite the respective stations.

It frequently occurs that the instrument has to be changed to points intermediate between two stations.

If in a five degrees curve, for instance, it is necessary to change the instrument from station No. 0, there being an obstruction in

the line of sight between station 0 and station No. 3, and nothing to prevent the instrument being set over a point in the curve 30 feet distant from station 2; the deflections would be made as follows:

Station	0	Deflection =	0° 00	B. C. 5° R.
"	1	"	2° 30.	
"	2	"	5° 00.	
"	2.30	"	5° 45.	* Change point.

Then move the instrument forward, and set it over station 2.30, and bring the cross hairs to bear on the staff at the beginning of the curve, station 0; then turn off 5° 45′ for tangent at station 2.30 and 1° 45′ for 70 feet the remainder of station No. 3, making in all for station No 3—deflections 7° 30′

"	4	"	10° 00′	
"	5	"	15° 00′	E. C.

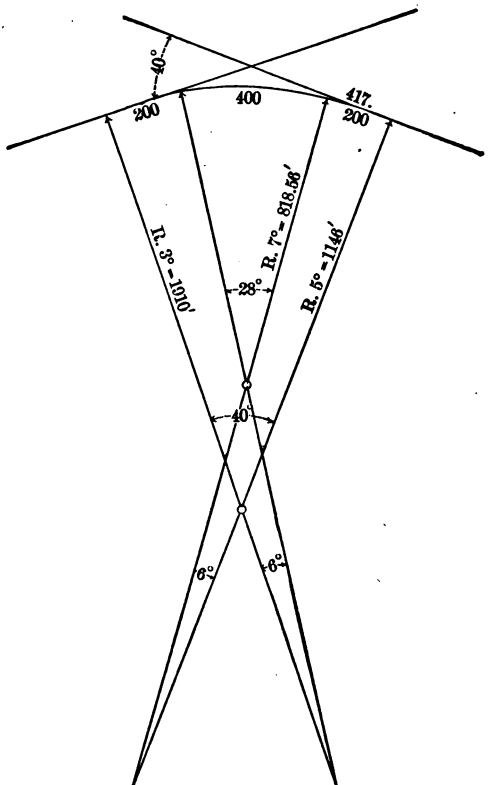
The angles for parts of a station on curves may be readily calculated and the angles turned off in such manner as will keep the stations of uniform length throughout the line.

REVERSE CURVES.

These may be put in according to the formation of the ground with equal radii, or not, as the case may require. In the latter case the degree of curve may be assumed and the curve continued as far as deemed necessary; and the tangent is then produced to the intersection and measured—and the angle of deflection determined. These give the data from which the radius and degree of curve are determined.—*See Pages* 6 *and* 7.

In the former case select a point in one of the tangents and turn from tangent such angle as the case may require, and measure on this line the distance between the tangents. Then set in a point one half of this distance for the point of reversion, from which both curves may be staked out.—*See Pages* 6 *and* 7.

If you wish to compound a curve so that the trains will pass less abruptly from tangent into and through the curve, it may be done in the following manner:



We will assume the angle of deflection to be 40°; in the tables under 40° and opposite 0′ find 2085.55, the distance from intersection of tangents to beginning of a one degree curve.

If you wi h to lay out a compound equivalent to a curve of 5° for the whole angle, divide the distance found (2085.55) by 5, degree of the curve; and you have the point of beginning 417 ft. from intersection of tangents. You will then decide on what length to substitute the less degree of curve.

If a 3° curve is decided on, and the distance 200 feet at each end of the 5° curve, then deduct 3° for each station of 100 feet, making

12° from the total angle of deflection, (40°) and you have 28° to be divided equally between the stations of the intermediate curve, or $\frac{28}{4} = 7°$, the required degree of curve.

FIELD NOTES.

No. of Station.	Course of chords.	Deflection.	REMARKS.
No 0.	" "	0° 00′	Beginning of curve,
1	N 1° 30′ W	1° 30′	
2	4 30	3 00	End of curve, 3°, B. C. 7°
3	9 30	3 30	From tangent.
4	16 30	7 00	
5	28 30	10 30	
6	30 30	14 00	E. C. 7°, B. C. 3°.
7	35 30	1 30	From tangent.
8	38 30	3 00	E. C. 3°. Tangent, N 40° W.

NATURAL TANGENTS.

From the tables may also be determined the natural tangent for any given number of degrees and minutes from one degree to 45°, by taking the distance given in the tables for twice the angle of which the tangent is sought, and dividing the same by 5730.

EXAMPLES :

1st. Required the natural tangent of 30°. Under 60° (twice the angle) find in the tables 3308.21 and divide the same by 5730, and you have the natural tangent for 30° = 0.57735.

2d. Required the natural tangent for an angle of 7° 28′; in the

column of distances under 14° and opposite 56′ (twice the angle) find 750.97, which divided by 5730 give the natural tangent for 7° 28′ equal to 0.13106.

MEASUREMENT WITH GUNTER'S CHAIN.

When a 66 feet chain is used for the length of stations, the radius of a one degree curve, 5730 feet, may represent 57.30 chains of 66 feet, and the distances in the tables applied the same as for chains of 100 feet in length; but the radius as well as the length of stations will be proportionally less than for stations of 100 feet in length by $\frac{3}{4}$ part.

If a 66 feet chain is used, the distance after being found in the tables, may be divided by 66, and the stations in the curve reduced to 75.76 links which are equal to 50 feet, one half the length of the stations generally adopted in staking the center line of railroads; and the curve staked out accordingly, turning off one half the number of degrees required for the stations of 100 feet in length.

The degree of curvature is understood to express the number of degrees per 100 feet, and hence the convenience of making the stations of such length as will give a definite idea of the degree of curve and length of radius.

The following abbreviations are used by some Engineers.

P. C. For Point of Curve, or Beginning of Curve.

P. T. " " " Tangent, or End of Curve.

P. C. C. " " " Compound Curve—or end of one curve and beginning of another, curving in the same direction.

P. R. C. " " " Reverse Curve, or point where the direction of the curve is changed from right to left, or *vice versa.*

P. I. " " " Intersection of Tangents.

RAILROAD CURVE TABLES.

RAILROAD CURVE TABLES.

′	0°	1°	2°	3°	4°	5°	6°	7°	8°	′
0	0.00	50.02	100.00	150.07	200.09	250.17	300.30	350.44	400.70	0
1	0.83	50.85	100.83	150.90	200.92	251.00	301.14	351.28	401.54	1
2	1.67	51.69	101.67	151.74	201.76	251.84	301.97	352.11	402.37	2
3	2.50	52.52	102.50	152.57	202.59	252.67	302.80	352.95	403.21	3
4	3.33	53.35	103.34	153.41	203.43	253.51	303.64	353.79	404.05	4
5	4.17	54.18	104.17	154.24	204.26	254.34	304.47	354.62	404.88	5
6	5.00	55.02	105.01	155.08	205.10	255.18	305.31	355.46	405.72	6
7	5.83	55.85	105.84	155.91	205.93	256.01	306.14	356.30	406.55	7
8	6.67	56.68	106.68	156.75	206.77	256.85	306.98	357.13	407.39	8
9	7.50	57.52	107.51	157.58	207.60	257.68	307.81	357.97	408.23	9
10	8.33	58.35	108.35	158.42	208.44	258.52	308.65	358.81	409.06	10
11	9.17	59.18	109.18	159.25	209.27	259.35	309.48	359.64	409.90	11
12	10.00	60.01	110.02	160.09	210.11	260.20	310.32	360.48	410.74	12
13	10.83	60.85	110.85	160.92	210.94	261.03	311.15	361.32	411.57	13
14	11.67	61.68	111.69	161.76	211.77	261.86	311.99	362.15	412.41	14
15	12.50	62.52	112.52	162.59	212.61	262.70	312.83	362.99	413.25	15
16	13.33	63.35	113.36	163.43	213.45	263.54	313.66	363.83	414.08	16
17	14.17	64.18	114.19	164.26	214.28	264.37	314.49	364.66	414.92	17
18	15.00	65.01	115.02	165.09	215.11	265.20	315.33	365.50	415.75	18
19	15.83	65.85	115.86	165.93	215.95	266.04	316.16	366.34	416.59	19
20	16.67	66.68	116.69	166.76	216.78	266.87	317.00	367.17	417.43	20
21	17.50	67.51	117.53	167.60	217.62	267.71	317.84	368.01	418.26	21
22	18.33	68.35	118.36	168.43	218.45	268.54	318.67	368.85	419.10	22
23	19.17	69.18	119.20	169.27	219.29	269.38	319.50	369.68	419.94	23
24	20.00	70.01	120.03	170.10	220.12	270.21	320.34	370.52	420.77	24
25	20.83	70.85	120.87	170.94	220 96	271.05	321.18	371.36	421.61	25
26	21.67	71.68	121.70	171.77	221 79	271.88	322.01	372.19	422.45	26
27	22.50	72.51	122.54	172.61	222.63	272.72	322.85	373.03	423.28	27
28	23.33	73.34	123.37	173.44	223.46	273.54	323.68	373.86	424.12	28
29	24.17	74.18	124.21	174.28	224.30	274.38	324.52	374.70	424.95	29
30	25 00	75.01	125.03	175.10	225.13	275.21	325.35	375 54	425.79	30
31	25.83	75.84	125.87	175.88	225.96	276.05	326.19	376.38	426.63	31
32	26.67	76.68	126.70	176.72	226.80	276.88	327.02	377.22	427.47	32
33	27.50	77.51	127.53	177.55	227.63	277.72	327.86	378.05	428.31	33
34	28.33	78.34	128.37	178.39	228 47	278.55	328.69	378.89	429.15	34
35	29.17	79.17	129.20	179.22	229.30	279.39	329.53	379.73	429.98	35
36	30.00	80.01	130.04	180.06	230.14	280.23	330.37	380.57	430.82	36
37	30.83	80.84	130.87	180.89	230.97	281.06	331.20	381.41	431.66	37
38	31.67	81.67	131.71	181.73	231.81	281.90	332.04	382.24	432.50	38
39	32.50	82.51	132.54	182.56	232.64	282.73	332.87	383.08	433.34	39
40	33.33	83.34	133.38	183.40	233.48	283.57	333.71	383.92	434.18	40
41	34.17	84.17	134.21	184.23	234.31	284.41	334.55	384.76	435.02	41
42	35.00	85.01	135.05	185.07	235.15	285.24	335.38	385.60	435.86	42
43	35.83	85.84	135.88	185.90	235.98	286.08	336.22	386.43	436.70	43
44	36.66	86.67	136.72	186.74	236.82	286.91	337.05	387.27	437.54	44
45	37.50	87.51	137.55	187.57	237.65	287.75	337.89	388.11	438.37	45
46	38.33	88.34	138.38	188.40	238.48	288.59	338.73	388.95	439.21	46
47	39.17	89.17	139.22	189.24	239.32	289.42	339.56	389.79	440.05	47
48	40.00	90.00	140.05	190.07	240.15	290.26	340.40	390.62	440.89	48
49	40.83	90.84	140.89	190.91	240.99	291.09	341.23	391.46	441.73	49
50	41.67	91.67	141 72	191.74	241.82	291.93	342.07	392.30	442.57	50
51	42.50	92.50	142.56	192.58	242.66	292.77	342.91	393.14	443.41	51
52	43.33	93.34	143.39	193.41	243.49	293.60	343.74	393.98	444.25	52
53	44.17	94.17	144.23	194.25	244.33	294.44	344.58	394.81	445.09	53
54	45.00	95.00	145.06	195.08	245.16	295.27	345.41	395.65	445.93	54
55	45.83	95.84	145.90	195.92	246.00	296.11	346.25	396.49	446.76	55
56	46.67	96.67	146.73	196.75	246.83	296.95	347.08	397.33	447.60	56
57	47.50	97.50	147.57	197.59	247.67	297.78	347.92	398.17	448.44	57
58	48.33	98.33	148.40	198.42	248.50	298.62	348.76	399.01	449.28	58
59	49.17	99.17	149.24	199.26	249.34	299.46	349.60	399.85	450.12	59

RAILROAD CURVE TABLES.

′	9°	10°	11°	12°	13°	14°	15°	16°	17°	′
0	450.95	501.32	551.74	602.22	652.87	703.53	754.35	805.29	856.35	0
1	451.79	502.16	552.58	603.06	653.71	704.38	755.20	806.14	857.20	1
2	452.63	503.00	553.42	603.91	654.56	705.23	756 05	806.99	858.05	2
3	453.47	503.84	554.26	604.75	655.40	706.07	756.89	807.84	858.90	3
4	454.31	504.68	555.10	605.60	656.25	706.92	757.74	808.64	859.76	4
5	455.14	505.52	555.94	606.44	657.09	707.77	758.59	809.54	860.61	5
6	455.98	506.36	556.78	607.28	657.93	708.62	759.44	810.39	861.46	6
7	456.82	507.20	557.62	608.13	658.78	709.47	760.29	811.24	862.31	7
8	457.66	508.04	558.46	608.97	659.62	710.31	761.13	812.09	863.16	8
9	458.50	508.88	559.30	609.82	660.47	711.16	761.98	812.94	864.01	9
10	459.34	509.72	560.14	610,66	661.31	712.01	762.83	813.79	864.87	10
11	460.18	510 56	560.98	611.50	662.15	712.86	763.68	814.64	865.72	11
12	461.02	511.40	561.82	612.35	663.00	713.71	764.53	815.49	866.57	12
13	461.86	512.24	562.66	613.19	663.84	714.55	765.37	816.34	867.42	13
14	462.70	513.08	563.50	614.04	664.69	715.40	766.22	817.19	868.27	14
15	463.53	513.92	564.34	614.88	665.53	716.25	767.07	818.04	869.12	15
16	464.37	514.76	565.18	615.72	666.37	717.10	767.92	818.89	869.98	16
17	465.21	515.60	566.02	616.57	667.22	717.95	768.77	819.74	870.83	17
18	466.05	516.44	566.86	617.41	668.06	718.79	769.61	820 59	871.68	18
19	466.89	517.28	567.70	618.26	668.91	719,64	770.46	821.44	872.53	19
20	467.73	518.12	568.54	619.10	669.75	720.49	771.31	822 29	873.38	20
21	468.57	518.96	569.38	619.94	670.59	721.35	772.16	823.14	874.23	21
22	469.41	519 80	570.22	620.79	671.44	722.20	773.01	823 99	875.09	22
23	470.25	520.64	571.06	621.63	672.28	723.04	773.85	824.84	875.94	23
24	471.08	521.48	571.90	622.48	673.13	723.89	774.70	825 69	876.79	24
25	471.92	522.32	572.74	623.32	673.97	724.74	775.55	826.54	877.64	25
26	472.76	523.16	573.58	624.16	674.81	725.59	776.40	827.39	878•49	26
27	473.60	524.01	574.42	625.01	675.66	726.44	777.35	828.24	879.34	27
28	474.43	524.85	575.27	625.85	676.51	727.28	778.09	829 09	880.20	28
29	475.26	525.69	576.11	626.70	677.35	728.13	778.94	829.94	881.05	29
30	476.10	526.53	576.95	627.55	678.20	728.97	779.79	830.79	881.90	30
31	476.94	527.37	577.79	628.39	679.04	729.82	780.64	831.64	882.75	31
32	477.78	528.21	578.63	629.24	679.89	730.66	781.49	832.49	883.61	32
33	478.62	529.05	579.48	630.08	680.73	731.51	782.34	833.35	884.46	33
34	479.46	529.89	580.32	630.93	681.58	732.35	783.19	834.20	885.32	34
35	480.30	530.73	581.16	631.77	682.42	733.20	784.04	835.05	886.17	35
36	481.14	531.57	582.00	632.61	683.26	734.05	784.89	835.90	887.02	36
37	481.99	532.41	582.84	633 46	684.11	734.89	785.74	836.75	887.88	37
38	482.83	533.25	583.69	634.30	684.95	735.74	786.59	837.61	888.73	38
39	483.67	534.09	584.53	635.15	685.80	736.58	787.44	838.46	889.59	39
40	484.51	534.93	585.37	635.99	686.64	737.43	788.29	839.31	890.44	40
41	485.35	535.77	586.21	636.83	687.48	738.28	789.14	840.16	891.29	41
42	486.19	536.61	587.05	637.68	688.33	739.12	789.99	841.01	89 .15	42
43	487.03	537.45	587.90	638.52	689.17	739.97	790.84	841.87	893.00	43
44	487.87	538.29	588.74	639.37	690.02	740.81	791.69	842.72	893.86	44
45	488.71	539.13	589.58	640.21	690.86	741.66	792.54	843.57	894.71	45
46	489 56	539.97	590.42	641.05	691.70	742.51	793.39	844.42	895 5	46
47	490.40	540.81	591.26	641.90	692.55	743.35	794.24	845.27	896.42	47
48	491.24	541.65	592,11	642.74	693.39	744.20	795.09	846.13	897.27	48
49	492.08	542.49	592.95	643.59	694.24	745.04	795.94	846.98	898.13	49
50	492.92	543.33	593.79	644.43	695.08	745.89	796.79	847.83	898.98	50
51	493.76	544.17	594.63	645.27	695.92	746.74	797.64	848.68	899.83	51
52	494.60	545.01	595.47	646.12	696.77	747.58	798.49	849.53	900.69	52
53	495.44	545.85	596.32	646.96	697.61	748.43	799.34	850.39	901.54	53
54	496.28	546.69	597.16	647.81	698.46	749.27	800.19	851.24	902.40	54
55	497.12	547.53	598.00	648.65	699.30	750.12	801.04	852.09	903.25	55
56	497.96	548.37	598.84	649.49	700.14	750.97	801.89	852.94	904.10	56
57	498.81	549.21	599.68	650.34	700.99	751.81	802.74	853.79	904.96	57
58	499.65	550.06	600.53	651.18	701.83	752.66	803.59	854.65	905.81	58
59	500.48	550.90	601.38	652.03	702.68	753.50	804.44	855.50	906.67	59

RAILROAD CURVE TABLES.

′	18°	19°	20°	21°	22°	23°	24°	25°	26°	′
0	907.52	958.86	1010.37	1062.00	1113.80	1165.76	1217.96	1270.28	1322.88	0
1	908.38	959.72	1011.23	1062.86	1114.67	1166.63	1218.83	1271.16	1323.76	1
2	909.23	960.57	1012.09	1063.73	1115.53	1167.50	1219.70	1272.03	1324.63	2
3	910.09	961.43	1012.95	1064.59	1116.40	1168.37	1220.57	1272.91	1325.51	3
4	910.94	962.30	1013.81	1065.45	1117.26	1169.24	1221.45	1273.79	1326.39	4
5	911.80	963.15	1014.67	1066.32	1118.13	1170.11	1222.32	1274.66	1327.27	5
6	912.65	964.00	1015.53	1067.18	1118.99	1170.98	1223.19	1275.54	1328.14	6
7	913.51	964.86	1016.39	1068.04	1119.86	1171.85	1224.06	1276.42	1329.02	7
8	914.36	965.72	1017.24	1068.91	1120.72	1172.71	1224.93	1277.29	1329.90	8
9	915.22	966.58	1018.10	1069.77	1121.59	1173.58	1225.80	1278.17	1330.78	9
10	916.07	967.43	1018.96	1070.63	1122.45	1174.45	1226.67	1279.05	1331.65	10
11	916.93	968.29	1019.82	1071.50	1123.32	1175.32	1227.54	1279.92	1332.53	11
12	917.78	969.15	1020.68	1072.36	1124.18	1176.19	1228.42	1280.80	1333.41	12
13	918.64	970.00	1021.54	1073.22	1125.05	1177.06	1229.29	1281.69	1334.28	13
14	919.49	970.86	1022.40	1074.09	1125.91	1177.93	1230.16	1282.55	1335.16	14
15	920.35	971.72	1023.26	1074.95	1126.78	1178.80	1231.03	1283.43	1336.04	15
16	921.20	972.58	1024.12	1075.81	1127.64	1179.67	1231.90	1284.31	1336.92	16
17	922.06	973.43	1024.98	1076.68	1128.50	1180.54	1232.77	1285.18	1337.79	17
18	922.91	974.29	1025.84	1077.54	1129.37	1181.41	1233.64	1286.06	1338.67	18
19	923.77	975.15	1026.70	1078.40	1130.24	1182.28	1234.51	1286.94	1339.55	19
20	924.63	976.01	1027.56	1079.27	1131.10	1183.15	1235.39	1287.81	1340.43	20
21	925.48	976.86	1028.42	1080.13	1131.97	1184.02	1236.26	1288.69	1341.30	21
22	926.34	977.72	1029.27	1080.99	1132.83	1184.88	1237.13	1289.57	1342.18	22
23	927.19	978.58	1030.13	1081.86	1133.70	1185.75	1238.00	1290.44	1343.06	23
24	928.05	979.44	1030.99	1082.72	1134.56	1186.62	1238.87	1291.32	1343.94	24
25	928.90	980.29	1031.85	1083.58	1135.43	1187.49	1239.74	1292.20	1344.81	25
26	929.76	981.15	1032.71	1084.45	1136.29	1188.36	1240.61	1293.07	1345.69	26
27	930.61	982.01	1033.57	1085.31	1137.16	1189.23	1241.49	1293.95	1346.57	27
28	931.47	982.86	1034.43	1086.17	1138.02	1190.10	1242.36	1294.83	1347.44	28
29	932.32	983.72	1035.29	1087.04	1138.89	1190.97	1243.23	1295.70	1348.32	29
30	933.18	984.58	1036.15	1087.90	1139.75	1191.84	1244.10	1296.58	1349.20	30
31	934.04	985.44	1037.01	1088.76	1140.62	1192.71	1244.97	1297.46	1350.08	31
32	934.89	986.30	1037.87	1089.63	1141.48	1193.58	1245.85	1298.33	1350.96	32
33	935.75	987.16	1038.74	1090.49	1142.35	1194.45	1246.72	1299.21	1351.85	33
34	936.60	988.02	1039.60	1091.35	1143.22	1195.32	1247.59	1300.09	1352.73	34
35	937.46	988.88	1040.46	1092.22	1144.09	1196.19	1248.46	1300.96	1353.61	35
36	938.32	989.74	1041.32	1093.08	1144.95	1197.06	1249.34	1301.84	1354.49	36
37	939.17	990.60	1042.18	1093.94	1145.82	1197.93	1250.21	1302.72	1355.37	37
38	940.03	991.46	1043.05	1094.81	1146.69	1198.80	1251.08	1303.59	1356.25	38
39	940.88	992.32	1043.91	1095.67	1147.55	1199.68	1251.95	1304.47	1357.14	39
40	941.74	993.18	1044.77	1096.53	1148.42	1200.55	1252.83	1305.35	1358.02	40
41	942.60	994.04	1045.63	1097.40	1149.29	1201.42	1253.70	1306.22	1358.90	41
42	943.45	994.90	1046.49	1098.26	1150.15	1202.29	1254.57	1307.10	1359.78	42
43	944.31	995.76	1047.36	1099.12	1151.02	1203.16	1255.44	1307.98	1360.66	43
44	945.16	996.62	1048.22	1099.99	1151.89	1204.03	1256.32	1308.85	1361.54	44
45	946.02	997.48	1049.08	1100.85	1152.76	1204.90	1257.19	1309.73	1362.43	45
46	946.88	998.34	1049.94	1101.71	1153.62	1205.77	1258.06	1310.61	1363.31	46
47	947.73	999.19	1050.80	1102.58	1154.49	1206.64	1258.93	1311.48	1364.19	47
48	948.59	1000.95	1051.67	1103.44	1155.36	1207.51	1259.81	1312.36	1365.07	48
49	949.44	1000.91	1052.53	1104.30	1156.22	1208.38	1260.68	1313.24	1365.95	49
50	950.30	1001.77	1053.39	1105.17	1157.09	1209.25	1261.55	1314.11	1366.83	50
51	951.16	1002.63	1054.25	1106.03	1157.96	1210.12	1262.42	1314.99	1367.72	51
52	952.01	1003.49	1055.11	1106.89	1158.82	1210.99	1263.30	1315.87	1368.60	52
53	952.87	1004.35	1055.98	1107.76	1159.69	1211.86	1264.17	1316.74	1369.48	53
54	953.72	1005.21	1056.84	1108.62	1160.56	1212.73	1265.04	1317.62	1370.36	54
55	954.58	1006.07	1057.70	1109.48	1161.43	1213.61	1265.92	1318.50	1371.24	55
56	955.44	1006.93	1058.56	1110.35	1162.29	1214.48	1266.79	1319.37	1372.12	56
57	956.29	1007.79	1059.42	1111.21	1163.16	1215.35	1267.66	1320.25	1373.01	57
58	957.15	1008.65	1060.28	1112.07	1164.03	1216.22	1268.53	1321.13	1373.89	58
59	958.00	1009.51	1061.14	1112.94	1164.89	1217.09	1269.41	1322.00	1374.77	59

RAILROAD CURVE TABLES.

′	27°	28°	29°	30°	31°	32°	33°	34°	35°	′
0	1375.65	1428.65	1481.89	1535.30	1589.04	1643.08	1697.28	1751.83	1806.67	0
1	1376.53	1429.54	1482.78	1536.20	1589.94	1643.98	1698.19	1752.74	1807.59	1
2	1377.41	1430.42	1483.67	1537.09	1590.84	1644.88	1699.10	1753.66	1808.50	2
3	1378.30	1431.31	1484.56	1537.99	1591.74	1645.78	1700.01	1754.57	1809.42	3
4	1379.18	1432.20	1485.45	1538.88	1592.64	1646.69	1700.92	1755.48	1810.34	4
5	1380.06	1433.08	1486.34	1539.78	1593.54	1647.59	1701.83	1756.40	1811.25	5
6	1380.94	1433.97	1487.23	1540.67	1594.44	1648.49	1702.74	1757.31	1812.17	6
7	1381.82	1434.86	1488.12	1541.57	1595.34	1649.39	1703.65	1758.22	1813.09	7
8	1382.70	1435.74	1489.01	1542.47	1596.24	1650.29	1704.55	1759.13	1814.00	8
9	1383.59	1436.63	1489.90	1543.36	1597.14	1651.19	1705.46	1760.05	1814.92	9
10	1384.47	1437.52	1490.79	1544.26	1598.04	1652.09	1706.37	1760.96	1815.84	10
11	1385.35	1438.40	1491.68	1545.15	1598.94	1652.99	1707.28	1761.87	1816.75	11
12	1386.23	1439.29	1492.57	1546.05	1599.84	1653.90	1708.19	1762.79	1817.67	12
13	1387.11	1440.18	1493.46	1546.94	1600.74	1654.80	1709.10	1763.70	1818.59	13
14	1387.99	1441.06	1494.35	1547.84	1601.64	1655.70	1710.01	1764.61	1819.50	14
15	1388.88	1441.95	1495.24	1548.74	1602.54	1656.60	1710.92	1765.53	1820.42	15
16	1389.76	1442.84	1496.13	1549.63	1603.44	1657.50	1711.83	1766.44	1821 34	16
17	1390.64	1443.72	1497.02	1550.53	1604.33	1658.40	1712.74	1767.35	1822.25	17
18	1391.52	1444.61	1497.91	1551.42	1605.23	1659.30	1713.65	1768.26	1823.17	18
19	1392.40	1445.50	1498.80	1552.32	1606.13	1660.20	1714.56	1769.18	1824.09	19
20	1393.28	1446.38	1499.69	1553.21	1607.03	1661.11	1715.47	1770.09	1825.00	20
21	1394.17	1447.27	1500.58	1554.11	1607.93	1662.01	1716.38	1771.00	1825.92	21
22	1395.05	1448.16	1501.47	1555.00	1608.83	1662.91	1717.28	1771.92	1826.84	22
23	1395.93	1449.04	1502.36	1555.90	1609.73	1663.81	1718.19	1772.83	1827.75	23
24	1396.81	1449.93	1503.25	1556.80	1610.63	1664.71	1719.10	1773.74	1828.67	24
25	1397.69	1450.82	1504.14	1557.69	1611.53	1665.61	1720.01	1774.66	1829.59	25
26	1398.57	1451.70	1505.03	1558.59	1612.43	1666.51	1720.92	1775.57	1830.50	26
27	1399.46	1452.59	1505.92	1559.48	1613.33	1667.42	1721.83	1776.48	1831.42	27
28	1400.34	1453.48	1506.81	1560.38	1614.23	1668.32	1722.74	1777.39	1832.34	28
29	1401.22	1454 36	1507.70	1561.28	1615.13	1669.22	1723.65	1778.31	1833.25	29
30	1402.10	1455.25	1508.59	1562.17	1616.03	1670.12	1724.56	1779.22	1834.17	30
31	1402.99	1456.14	1509.48	1563.07	1616.93	1671.03	1725.47	1780.14	1835.09	31
32	1403.87	1457.03	1510.37	1563.96	1617.83	1671.93	1726.38	1781.05	1836.01	32
33	1404.76	1457.91	1511.26	1564.86	1618.74	1672.84	1727.29	1781.97	1836.93	33
34	1405.64	1458.80	1512.15	1565.75	1619.64	1673.74	1728.20	1782.88	1837.85	34
35	1406.53	1459.69	1513.04	1566.65	1620.54	1674.65	1729.10	1783.80	1838.77	35
36	1407.41	1460.58	1513.93	1567.54	1621.44	1675.55	1730.01	1784.71	1839.69	36
37	1408.30	1461.47	1514.82	1568.44	1622.34	1676.46	1730.92	1785.63	1840.61	37
38	1409.18	1462.35	1515.71	1569.34	1623.24	1677.36	1731.83	1786.54	1841.54	38
39	1410.07	1463.24	1516.60	1570.23	1624.15	1678.27	1732.74	1787.46	1842.46	39
40	1410.95	1464.13	1517.49	1571.13	1625.05	1679.17	1733.65	1788.37	1843.38	40
41	1411.84	1465.02	1518.38	1572.02	1625.95	1680.08	1734.56	1789.29	1844.30	41
42	1412.72	1465.91	1519.27	1572.92	1626.85	1680.98	1735.47	1790.20	1845.22	42
43	1413.61	1466.79	1520.16	1573.81	1627.75	1681.89	1736.38	1791.12	1846.14	43
44	1414.49	1467.68	1521.05	1574.71	1628.65	1682.79	1737.29	1792.03	1847.06	44
45	1415.38	1468.57	1521.94	1575.61	1629.56	1683.70	1738.20	1792.95	1847.98	45
46	1416.26	1469.46	1522.83	1576.50	1630.46	1684.61	1739 10	1793.86	1848.90	46
47	1417.15	1470.35	1523.73	1577.40	1631.36	1685.51	1740.01	1794.78	1849.82	47
48	1418.03	1471.23	1524.62	1578.29	1632.26	1686.42	1740.92	1795.69	1850.74	48
49	1418.92	1472.12	1525.51	1579,19	1633.16	1687.32	1741.83	1796.61	1851.66	49
50	1419.80	1473.01	1526.40	1580.08	1634.06	1688.23	1742.74	1797.52	1852.58	50
51	1420.69	1473.90	1527.29	1580.98	1634.97	1689.13	1743.65	1798.44	1853.50	51
52	1421.57	1474.79	1528.18	1581.88	1635.87	1690.04	1744.56	1799.35	1854.43	52
53	1422.46	1475.67	1529.07	1582.77	1636,77	1690.94	1745.47	1800.27	1855.35	53
54	1423.34	1476.56	1529.96	1583.67	1637.67	1691.85	1746.38	1801.18	1856,27	54
55	1424.23	1477.45	1530.85	1584.56	1638.57	1692.75	1747,29	1802.10	1857.19	55
56	1425.11	1478.34	1531.74	1585.46	1639.47	1693.66	1748.19	1803.01	1858.11	56
57	1425.99	1479.23	1532.63	1586.35	1640.38	1694.56	1749.10	1803.93	1859.03	57
58	1426.88	1480.11	1533.52	1587.25	1641.28	1695.47	1750.01	1804.84	1859.95	58
59	1427.77	1481.00	1534.41	1588.15	1642.18	1696.37	1750.92	1805.76	1860,87	59

RAILROAD CURVE TABLES.

′	36°	37°	38°	39°	40°	41°	42°	43°	44°	′
0	1861.79	1917.26	1973.01	2029.11	2085.55	2142.33	2199.52	2257.10	2315.09	0
1	1862.71	1918.19	1973.94	2030.05	2086.50	2143.28	2200.48	2258.06	2316.06	1
2	1863.64	1919.11	1974.88	2030.99	2087.44	2144.24	2201.44	2259.03	2317.03	2
3	1864.56	1920.04	1975.81	2031.93	2088.39	2145.19	2202.40	2259.99	2318.00	3
4	1865.48	1920.97	1976.75	2032.87	2089.33	2146.14	2203.35	2260.96	2318.97	4
5	1866.41	1921.89	1977.68	2033.81	2090.28	2147.10	2204.31	2261.92	2319.94	5
6	1867.33	1922.82	1978.61	2034.75	2091.22	2148.05	2205.27	2262.89	2320.91	6
7	1868.25	1923.74	1979.55	2035.69	2092.17	2149.00	2206.23	2263.85	2321.88	7
8	1869.17	1924.67	1980.48	2036.63	2093.11	2149.95	2207.19	2264.82	2322.85	8
9	1870.10	1925.60	1981.42	2037.67	2094.06	2150.91	2208.15	2265.78	2323.82	9
10	1871.02	1926.52	1982.35	2038.51	2095.00	2151.86	2209.11	2266.75	2324.79	10
11	1871.94	1927.45	1983.28	2039.45	2095.95	2152.81	2210.07	2267.71	2325.76	11
12	1872.86	1928.38	1984.22	2040.39	2096.89	2153.77	2211.02	2268.68	2326.73	12
13	1873.78	1929.30	1985.15	2041.33	2097.84	2154.72	2211.98	2269.64	2327.70	13
14	1874.71	1930.23	1986.09	2042.27	2098.78	2155.67	2212.94	2270.61	2328.67	14
15	1875.63	1931.15	1987.02	2043.21	2099.73	2156.63	2213.90	2271.57	2329.64	15
16	1876.55	1932.08	1987.95	2044.15	2100.67	2157.58	2214.86	2272.54	2330.61	16
17	1877.48	1933.01	1988.89	2045.08	2101.62	2158 53	2215.82	2273.50	2331.59	17
18	1878.40	1933.93	1989.82	2046.02	2102.57	2159.48	2216.78	2274.46	2332.56	18
19	1879.32	1934.86	1990.76	2046.96	2103.51	2160.44	2217.74	2275.43	2333.52	19
20	1880.24	1935.79	1991.69	2047.90	2104.46	2161.39	2218.69	2276.39	2334.49	20
21	1881.16	1936.71	1992.62	2048.84	2105.40	2162.34	2219.65	2277.36	2335.46	21
22	1882.09	1937.64	1993.56	2049.78	2106.35	2163.30	2220.61	2278.32	2336.44	22
23	1883.01	1938.56	1994.49	2050.72	2107.29	2164.25	2221.57	2279.29	2337.41	23
24	1883.93	1939.49	1995.43	2051.66	2108.24	2165.20	2222.53	2280.25	2338.38	24
25	1884.86	1940.42	1996.36	2052.60	2109.18	2166.16	2223.49	2281 22	2339.35	25
26	1885.78	1941.34	1997.29	2053.54	2110.13	2167.11	2224.45	2282.18	2340.32	26
27	1886.71	1942.27	1998.23	2054.48	2111.07	2168.06	2225.40	2283.15	2341.29	27
28	1887.63	1943.20	1999.16	2055.42	2112.02	2169.01	2226.36	2284.11	2342.26	28
29	1888.55	1944.12	2000.10	2056.36	2112.96	2169.97	2227.32	2285.08	2343.23	29
30	1889.47	1945.05	2001.03	2057.30	2113.91	2170.92	2228.28	2286.04	2344.20	30
31	1890.40	1945.98	2001.97	2058.24	2114.86	2171.87	2229.24	2287.01	2345.17	31
32	1891.32	1946.91	2002.90	2059.18	2115.80	2172.83	2230.20	2287.98	2346.15	32
33	1892.25	1947.85	2003.84	2060.13	2116.75	2173.78	2231.16	2288.94	2347.12	33
34	1893.17	1948.78	2004.77	2061.07	2117.70	2174.73	2232.12	2289.91	2348.10	34
35	1894.10	1949.71	2005.71	2062.01	2118.65	2175 69	2233 08	2290.88	2349 07	35
36	1895.03	1950.64	2006.65	2062.95	2119.59	2176.64	2234.04	2291.85	2350.04	36
37	1895.95	1951.57	2007.58	2063.89	2120.54	2177.59	2235 00	2292.82	2351.02	37
38	1896.88	1952.51	2008.52	2064.83	2121.49	2178.55	2235.97	2293.79	2351.99	38
39	1897.81	1953.44	2009.45	2065.78	2122.44	2179.50	2236.93	2294.75	2352.97	39
40	1898.73	1954.37	2010.39	2066.72	2123.38	2180.45	2237.89	2295.72	2353.94	40
41	1899.66	1955.30	2011.33	2067.66	2124.33	2181.41	2238.85	2296.69	2354.91	41
42	1900.59	1956.23	2012.26	2068.60	2125.28	2182.36	2239.81	2297.66	2355.89	42
43	1901.51	1957.17	2013.20	2069.54	2126.22	2183.31	2240.77	2298.63	2356 86	43
44	1902.44	1958.10	2014.34	2070.48	2127.17	2184.27	2241.73	2299.60	2357.84	44
45	1903.36	1959.03	2015.07	2071.43	2128.12	2185.23	2242.69	2300.56	2358.81	45
46	1904.29	1959.96	2016.01	2072.37	2129.07	2186.17	2243.65	2301.53	2359.78	46
47	1905.22	1960.89	2016.94	2073.31	2130.01	2187.13	2244.61	2302.50	2360 76	47
48	1906.14	1961.83	2017.88	2074.25	2130.96	2188.08	2245.57	2303.47	2361.73	48
49	1907.07	1962.76	2018.81	2075.19	2131.91	2189.03	2246.53	2304.44	2362.71	49
50	1908.00	1963.69	2019.75	2076.13	2132.86	2189.99	2247.49	2305.41	2363.68	50
51	1908.92	1964.62	2020.69	2077.08	2133.80	2190.94	2248.45	2306.37	2364.65	51
52	1909.85	1965.55	2021.62	2078.02	2134.75	2191.89	2249 42	2307.34	2365.63	52
53	1910.77	1966.49	2022.56	2078.99	2135.70	2192.85	2250.38	2308 31	2366.60	53
54	1911.70	1967.42	2023.49	2079.90	2136.65	2193.80	2251.34	2309.28	2367.58	54
55	1912.63	1968.35	2024.43	2080.84	2137.59	2194.75	2252.30	2310.25	2368.55	55
56	1913.55	1969.28	2025.37	2081.78	2138.54	2195.71	2253.26	2311.22	2369.52	56
57	1914.48	1970.21	2026.30	2082.73	2139.49	2196.66	2254.22	2312.18	2370.50	57
58	1915.41	1971.15	2027.24	2083.67	2140.43	2197.61	2255.18	2313.15	2371.47	58
59	1916.33	1972.08	2028.17	2084.61	2141.38	2198.57	2256.14	2314.21	2372.45	59

RAILROAD CURVE TABLES.

′	45°	46°	47°	48°	49°	50°	51°	52°	53°	′
0	2373.42	2432.21	2491.46	2551.11	2611.27	2671.90	2733.04	2794.69	2856.86	0
1	2374.40	2433.20	2492.45	2552.11	2612.28	2672.92	2734.07	2795.72	2857.90	1
2	2375.38	2434.18	2493.45	2553.11	2613.29	2673.94	2735.09	2796.76	2858.95	2
3	2376.35	2435.17	2494.44	2554.11	2614.30	2674.95	2736.12	2797.79	2859.99	3
4	2377.33	2436.15	2495.43	2555.11	2615.31	2675.97	2737.14	2798.82	2861.03	4
5	2378.31	2437.14	2496.43	2556.11	2616.32	2676.99	2738.17	2799.86	2862.08	5
6	2379.29	2438.12	2497.42	2557.12	2617.32	2678.01	2739.19	2800.89	2863.12	6
7	2380.27	2439.11	2498.41	2558.12	2618.33	2679 03	2740.22	2801.92	2864.16	7
8	2381.24	2440.10	2469.40	2559.12	2619.34	2680.04	2741.25	2802.96	2865.20	8
9	2382.22	2441.08	2500.40	2560.12	2620.35	2681.06	2742.27	2803.99	2866.25	9
10	2383.20	2442.07	2501.39	2561.12	2621.36	2682.08	2743.30	2805.02	2867.29	10
11	2384.18	2443.05	2502.38	2562.12	2622.36	2683.10	2744.32	2806.06	2868.33	11
12	2385.16	2444.04	2503.38	2563.12	2623.37	2684.12	2745.35	2807.09	2869.38	12
13	2386.13	2445.02	2504.37	2564.12	2624.38	2685.13	2746.37	2808.12	2870.42	13
14	2387.11	2446.01	2505.36	2565.12	2625.39	2686.15	2747.40	2809.16	2871.46	14
15	2388.09	2447.00	2506.36	2566.12	2626.40	2687.17	2748.43	2810.19	2872.51	15
16	2389.07	2447.98	2507.35	2567.13	2627.41	2688.19	2749.45	2811.22	2873.55	16
17	2390.05	2448.97	2508.34	2568.13	2628.41	2689.21	2750.48	2812.26	2874.59	17
18	2391.02	2449.95	2509.33	2569.13	2629.42	2690.22	2751.50	2813.29	2875.63	18
19	2392.00	2450.94	2510.33	2570.13	2630.43	2691.24	2752.53	2814.32	2876.68	19
20	2392.98	2451.92	2511.32	2571.13	2631.44	2692.26	2753.55	2815 36	2877.72	20
21	2393.96	2452.91	2512.32	2572.13	2632.45	2693.28	2754.58	2816.39	2878.76	21
22	2394.94	2453.89	2513.31	2573.13	2633.46	2694.30	2755.61	2817.42	2879.81	22
23	2395.91	2454.88	2514.30	2574.13	2634.47	2695.31	2756.63	2818.46	2880.85	23
24	2396.89	2455.87	2515.30	2575.13	2635.48	2696.33	2757.66	2819.49	2881.89	24
25	2397.87	2456.85	2516.29	2576.13	2636.49	2697.35	2758.68	2820.52	2882.94	25
26	2398.85	2457.84	2517.28	2577.13	2637.50	2698.37	2759.71	2821.56	2883.98	26
27	2399.83	2458.82	2518.27	2578.13	2638.50	2699.39	2760.73	2822.59	2885.02	27
28	2400.80	2459.81	2519.27	2579.13	2639.51	2700.40	2761.76	2823.62	2886.06	28
29	2401.78	2460.80	2520.26	2580.13	2640.52	2701.42	2762.79	2824.66	2887.11	29
30	2402.76	2461.78	2521.25	2581.13	2641.53	2702.44	2763.81	2825.69	2888.15	30
31	2403.74	2462.77	2522.25	2582 13	2642.54	2703.46	2764.84	2826.73	2889.20	31
32	2404.72	2463.76	2523.24	2583.14	2643.55	2704.48	2765.87	2827.77	2890.24	32
33	2405.71	2464.75	2524.24	2584.14	2644.57	2705.50	2766.90	2828.81	2891.29	33
34	2406.69	2465.74	2525.23	2585.15	2645.58	2706.52	2767.93	2829.85	2892.34	34
35	2407.67	2466.73	2526.23	2586.15	2646 59	2707.54	2768.96	2830.89	2893.39	35
36	2408.65	2467.72	2527.22	2587.16	2647.60	2708.56	2769.99	2831.92	2894.43	36
37	2409.63	2468.71	2528.22	2588.16	2648.62	2709.58	2771.02	2832.96	2895.48	37
38	2410.61	2469.69	2529.21	2589.17	2649.63	2710.60	2772.04	2834.00	2896.53	38
39	2411.60	2470.68	2530.21	2590.17	2650.64	2711.62	2773.07	2835.04	2897.57	39
40	2412.58	2471.67	2531.20	2591.18	2651.65	2712.64	2774.10	2836.08	2898.62	40
41	2413.56	2472.66	2532.20	2592.18	2652.67	2713.66	2775.13	2837.12	2899.67	41
42	2414.54	2473.65	2533.19	2593.18	2653.68	2714.68	2776.16	2838.16	2900.71	42
43	2415.52	2474.64	2534.19	2594 19	2654.69	2715.70	2777.19	2839.20	2901.76	43
44	2416.50	2475.63	2535.18	2595.19	2655.70	2716.72	2778.22	2840.24	2902.81	44
45	2417.49	2476.62	2536.18	2596.20	2656.71	2717.74	2779.25	2841.28	2903.86	45
46	2418.47	2477.61	2537.17	2597.20	2657.73	2718.76	2780.28	2842.31	2904.90	46
47	2419.45	2478.60	2538.17	2598.21	2658.74	2719.78	2781.31	2843.35	2905.95	47
48	2420.43	2479.59	2539.17	2599.21	2659.75	2720.80	2782.34	2844.39	2907.00	48
49	2421.41	2480.58	2540.16	2600 22	2660.76	2721.82	2783.37	2845 43	2908 04	49
50	2422.39	2481.57	2541.16	2601.22	2661.78	2722.84	2784.40	2846.47	2909.09	50
51	2423.38	2482.56	2542.15	2602.23	2662.79	2723.86	2 85.43	2847.51	2910.14	51
52	2424.36	2483.54	2543.15	2603.23	2663.80	2724.88	2786.45	2848 55	2911.18	52
53	2425.34	2484.53	2544.14	2604.24	2664.81	2725.90	2787.48	2849 59	2912.23	53
54	2426.32	2485.52	2545.14	2605.24	2665.83	2726.92	2788.51	2850.63	2913.28	54
55	2427.30	2486.51	2546.13	2606.24	2666.84	2727.94	2789.54	2851.67	2914.32	55
56	2428.28	2487.50	2547.13	26 7.25	2667.85	2728 96	2790.57	2852.70	2915.36	56
57	2429.27	2488.49	2548.12	2608.25	2668.86	2729.98	2791.60	2853.74	2916.41	57
58	2430.25	2489.48	2549.12	2609.26	2669.87	2731.00	2792.63	2854.78	2917.46	58
59	2431.23	2490.47	2550.11	2610.26	2670.89	2732.02	2793.66	2855.82	2918.50	59

RAILROAD CURVE TABLES.

′	54°	55°	56°	57°	58°	59°	60°	61°	62°	′
0	2919.55	2982.81	3046.64	3111.10	3176.14	3241.86	3308.21	3375.20	3442.93	0
1	2920.60	2983.87	3047.71	3112.18	3177.23	3242.96	3309.32	3376.33	3444.07	1
2	2921.65	2984.93	3048.78	3113.26	3178.32	3244.06	3310.44	3377.45	3445.20	2
3	2922.71	2986.00	3049.86	3114.34	3179.42	3245.17	3311.55	3378.58	3446.34	3
4	2923.76	2987.06	3050.93	3115.42	3180.51	3246.27	3312.67	3379.70	3447.48	4
5	2924.81	2988.12	3052.00	3116.51	3181.60	3247.37	3313.78	3380.83	3448.61	5
6	2925.86	2989.18	3053.07	3117.59	3182.69	3248.47	3314.89	3381.95	3449.75	6
7	2926.92	2990.24	3054.14	3118.67	3183.79	3249.57	3316.01	3383.08	3450.88	7
8	2927.97	2991.31	3055.21	3119.75	3184.88	3250.68	3317.12	3384.20	3452.02	8
9	2929.02	2992.37	3056.29	3120.83	3185.97	3251.78	3318.24	3385.33	3453.16	9
10	2930.07	2993.43	3057.36	3121.91	3187.06	3252.88	3319.35	3386.45	3454.29	10
11	2931.13	2994.49	3058.43	3122.99	3188.16	3253.98	3320.46	3387.58	3455.43	11
12	2932.18	2995.55	3059.50	3124.07	3189.25	3255.08	3321.58	3388.70	3456.57	12
13	2933.23	2996.62	3060.57	3125.15	3190.34	3256.19	3322.69	3389.83	3457.70	13
14	2934.28	2997.68	3061.64	3126.23	3191.43	3257.29	3323.80	3390.95	3458.84	14
15	2935.33	2998.74	3062.72	3127.32	3192.52	3258.39	3324.92	3392.08	3459.97	15
16	2936.39	2999.80	3063.79	3128.40	3193.62	3259.49	3326.03	3393.20	3461.11	16
17	2937.44	3000.86	3064.86	3129.48	3194.71	3260.59	3327.15	3394.33	3462.25	17
18	2938.49	3001.93	3065.93	3130.56	3195.80	3261.70	3328.26	3395.45	3463.38	18
19	2939.54	3002.99	3067.00	3131.64	3196.89	3262.80	3329.36	3396.58	3464.52	19
20	2940.60	3004.05	3068.07	3132.72	3197.99	3263.90	3330.49	3397.70	3465.66	20
21	2941.65	3005.11	3069.15	3133.80	3199.08	3265.00	3331.60	3398.83	3466.79	21
22	2942.70	3006.17	3070.22	3134.88	3200.17	3266.10	3332.71	3399.95	3467.93	22
23	2943.75	3007.24	3071.29	3135.96	3201.26	3267.21	3333.83	3401.08	3469.07	23
24	2944.81	3008.30	3072.36	3137.04	3202.36	3268.31	3334.94	3402.20	3470.20	24
25	2945.86	3009.36	3073.43	3138.13	3203.45	3269.41	3336.05	3403.33	3471.34	25
26	2946.91	3010.42	3074.50	3139.21	3204.54	3270.51	3337.17	3404.45	3472.47	26
27	2947.96	3011.48	3075.58	3140.29	3205.63	3271.61	3338.28	3405.58	3473.61	27
28	2949.01	3012.55	3076.65	3141.37	3206.73	3272.72	3339.40	3406.70	3474.75	28
29	2950.07	3013.61	3077.72	3142.45	3207.82	3273.82	3340.51	3407.83	3475.88	29
30	2951.12	3014.67	3078.79	3143.53	3208.91	3274.92	3341.62	3408.95	3477.02	30
31	2952.18	3015.74	3079.87	3144.62	3210.01	3276.03	3342.74	3410.08	3478.16	31
32	2953.23	3016.80	3080.94	3145.70	3211.11	3277.14	3343.86	3411.22	3479.31	32
33	2954.29	3017.87	3082.02	3146.79	3212.20	3278.25	3344.98	3412.35	3480.45	33
34	2955.35	3018.93	3083.10	3147.88	3213.30	3279.36	3346.10	3413.48	3481.60	34
35	2956.40	3020.00	3084.18	3148.97	3214.40	3280.47	3347.22	3414.61	3482.74	35
36	2957.46	3021.06	3085.25	3150.05	3215.50	3281.58	3348.34	3415.75	3483.88	36
37	2958.51	3022.13	3086.33	3151.14	3216.60	3282.69	3349.46	3416.88	3485.03	37
38	2959.57	3023.20	3087.41	3152.23	3217.70	3283.80	3350.58	3418.01	3486.17	38
39	2960.63	3024.26	3088.48	3153.31	3218.80	3284.91	3351.69	3419.14	3487.32	39
40	2961.68	3025.33	3089.56	3154.40	3219.89	3286.02	3352.81	3420.28	3488.46	40
41	2962.74	3026.39	3090.64	3155.49	3220.99	3287.13	3353.93	3421.41	3489.60	41
42	2963.80	3027.46	3091.71	3156.57	3222.09	3288.24	3355.05	3422.54	3490.75	42
43	2964.85	3028.52	3092.79	3157.66	3223.19	3289.35	3356.17	3423.68	3491.89	43
44	2965.91	3029.59	3093.87	3158.75	3224.29	3290.46	3357.29	3424.81	3493.04	44
45	2966.96	3030.66	3094.95	3159.84	3225.38	3291.57	3358.41	3425.94	3494.18	45
46	2968.02	3031.72	3096.03	3160.92	3226.48	3292.68	3359.53	3427.07	3495.32	46
47	2969.08	3032.79	3097.10	3162.01	3227.58	3293.78	3360.65	3428.21	3496.47	47
48	2970.13	3033.85	3098.18	3163.10	3228.68	3294.89	3361.77	3429.34	3497.61	48
49	2971.19	3034.92	3099.25	3164.18	3229.78	3296.00	3362.89	3430.47	3498.77	49
50	2972.25	3035.98	3100.33	3165.27	3230.88	3297.11	3364.01	3431.60	3499.90	50
51	2973.30	3037.05	3101.41	3166.36	3231.97	3298.22	3365.13	3432.74	3501.04	51
52	2974.36	3038.11	3102.48	3167.44	3233.07	3299.33	3366.25	3433.87	3502.19	52
53	2975.41	3039.18	3103.56	3168.53	3234.17	3300.44	3367.37	3435.00	3503.33	53
54	2976.47	3040.25	3104.64	3169.62	3235.27	3301.55	3368.48	3436.13	3504.48	54
55	2977.53	3041.31	3105.72	3170.71	3236.37	3302.66	3369.60	3437.27	3505.62	55
56	2978.58	3042.38	3106.79	3171.79	3237.47	3303.77	3370.72	3438.40	3506.76	56
57	2979.64	3043.44	3107.87	3172.88	3238.56	3304.88	3371.84	3439.53	3507.91	57
58	2980.70	3044.51	3108.95	3173.97	3239.66	3305.99	3372.96	3440.67	3509.05	58
59	2981.75	3045.57	3110.02	3175.05	3240.76	3307.10	3374.08	3441.80	3510.20	59

RAILROAD CURVE TABLES.

′	63°	64°	65°	66°	67°	68°	69°	70°	71°	′
0	3511.34	3580.45	3650.41	3721.06	3792.57	3864.88	3938.11	4012.15	4087.15	0
1	3512.49	3581.61	3651.59	3722.25	3793.77	3866.10	3939.34	4013.40	4088.41	1
2	3513.64	3582.78	3652.76	3723.44	3794.97	3867.31	3940.57	4014.64	4089.67	2
3	3514.78	3583.94	3653.94	3724.62	3796.17	3868.53	3941.80	4015.89	4090.93	3
4	3515.93	3585.10	3655.11	3725.81	3797.38	3869.75	3943.03	4017 14	4092.19	4
5	3517.08	3586.27	3656.29	3727.00	3798.58	3870.97	3944.26	4018.39	4093.45	5
6	3518.23	3587.43	3657.46	3728.19	3799.78	3872.18	3945.49	4019.63	4094.71	6
7	3519.38	3588.59	3658.64	3729.38	3800.98	3873.40	3946.72	4020.88	4095.97	7
8	3520.52	3589.75	3659.81	3730.56	3802.18	3874.62	3947.95	4022.13	4097.24	8
9	3521.67	3590.92	3660.99	3731.75	3803.38	3875.83	3949.18	4023.37	4098.50	9
10	3522.82	3592.08	3662.16	3732.94	3804.58	3877.05	3950.41	4024.62	4099.76	10
11	3523.97	3593.24	3663.33	3734.13	3805.78	3878.27	3951.64	4025.87	4101.02	11
12	3525.12	3594.41	3664.51	3735.32	3806.99	3879.48	3952.87	4027.11	4102.28	12
13	3526.26	3595.57	3665 68	3736.50	3808.19	3880.70	3954.10	4028.36	4103.54	13
14	3527.41	3596.73	3666.86	3737.69	3809.39	3881.92	3955.33	4029.61	4104.80	14
15	3528.56	3597.90	3668.03	3738.88	3810.59	3883.14	3956.56	4 30.86	4106.06	15
16	3529.71	3599.06	3669.21	3740.07	3811.79	3884.35	3957.79	4032.10	4107.32	16
17	3530.86	3600.22	3670.38	3741.26	3812.99	3885.57	3959.02	4033.35	4108 58	17
18	3532.00	3601.38	3671.56	3742.44	3814.19	3886.79	3960.25	4034.60	4109.84	18
19	3533.15	3602.55	3672.73	3743.63	3815.39	3888.00	3961.48	4035.84	4111.10	19
20	3534.30	3603.71	3673.90	3744.83	3816.60	3889.21	3962.71	4037.09	4112.36	20
21	3535.45	3604.87	3675.08	3746.01	3817.80	3890.43	3963.94	4038.34	4113.62	21
22	3536.60	3606.04	3676.25	3747.20	3819.00	3891.64	3965.17	4039.58	4114.89	22
23	3537.74	3607.20	3677.43	3748.38	3820.20	3892.86	3966.40	4040.83	4116.15	23
24	3538.89	3608.36	3678.60	3749.57	3821.40	3894.08	3967.63	4042.08	4117.41	24
25	3540.04	3609.53	3679.78	3750.76	3822.60	3895.29	3968.86	4043.33	4118.67	25
26	3541.19	3610.69	3680.95	3751.95	3823.80	3896.51	3970.09	4044.57	4119.93	26
27	3542.34	3611.85	3682.13	3753.14	3825.01	3897.73	3971.32	4045.82	4121.19	27
28	3543.48	3613.01	3683.30	3754.32	3826.21	3898.95	3972.55	4047.07	4122.45	28
29	3544.63	3614.18	3684.48	3755.51	3827.41	3900.16	3973.78	4048.31	4123.71	29
30	3545.78	3615.34	3685.65	3756.70	3828.61	3901.38	3975.01	4049.56	4124.97	30
31	3546.94	3616.51	3686.83	3757.90	3829.82	3902.60	3976.25	4050.81	4126.24	31
32	3548.09	3617.68	3688.01	3759.09	3831.03	3903.83	3977.49	4052.07	4127.51	32
33	3549.25	3618.85	3689.19	3760.29	3832.24	3905.05	3978.72	4053.32	4128.78	33
34	3550.40	3620.02	3690.37	3761.48	3833.45	3906.28	3979.96	4054.57	4130.05	34
35	3551.56	3621.19	3691.55	3762.68	3834.66	3907.50	3981.20	4055.83	4131.32	35
36	3552.72	3622.35	3692.73	3763.87	3835.86	3908.73	3982.44	4057.08	4132.59	36
37	3553.87	3623.52	3693.91	3765.07	3837.07	3909.95	3983.68	4058.33	4133.86	37
38	3555.03	3624.69	3695.09	3766.27	3838.28	3911.17	3984.91	4059.58	4135.13	38
39	3556.18	3625.86	3696.27	3767.46	3839.49	3912.40	3986.15	4060.84	4136.40	39
40	3557.34	3627.03	3697.45	3768.66	3840.70	3913.62	3987.39	4062.09	4137.67	40
41	3558.49	3628.20	3698.63	3769.85	3841.91	3914.85	3988.63	4063.34	4138.94	41
42	3559.65	3629.37	3699.81	3771.05	3843.12	3916.07	3989.87	4064.60	4140.21	42
43	3560.80	3630.54	8 00.99	3772.24	3844.33	3917.30	3991.10	4065.85	4141.48	43
44	3561.96	3631.71	3702.17	3773.44	3845.54	3918.52	3992.34	4067.10	4142.75	44
45	3563.12	3632.88	3703.35	3774.64	3846.75	3919.74	3993.58	4068.36	4144.02	45
46	3564.27	3634.04	3704.53	3775.83	3847.95	3920.97	3994.82	4069.61	4145.29	46
47	3565.43	3635.21	3705.72	3777.03	3849.16	3922.19	3996.06	4070.86	4146.56	47
48	3566.58	3636.38	3706.90	3778.22	3850.37	3923.42	3997.29	4072.11	4147.83	48
49	3567.74	3637.55	3708.08	3779.42	3851.58	3924.64	3998.53	4073.37	4149 10	49
50	3568.89	3638.72	3709.26	3780.61	3852.79	3925.87	3999.77	4074.62	4150.37	50
51	3570.05	3639.89	3710.44	3781.81	3854.00	3927.09	4001.01	4075.87	4151.64	51
52	3571.21	3641.06	3711.62	3783.01	3855.21	3928.31	4002.25	4077.13	4152.91	52
53	3572.36	3642.23	3712.80	3784.20	3856.42	3929.54	4003 48	4078.38	4154.18	53
54	3573.52	3643.40	3713.98	3785.40	3857.63	3930.76	4004.72	4079.63	4155.45	54
55	3574.67	3644.57	3715.16	3786.59	3858.84	3931.99	4005.96	4080.89	4156.72	55
56	3575.83	3645.73	3716.34	3787.79	3860.04	3933.21	4007.20	4082.14	4157.99	56
57	3576.99	3646.90	3717.52	3788.98	3861.25	3934.44	4008.44	4083.39	4159.26	57
58	3578.14	3648.07	3718.70	3790.18	3862.46	3935.66	4009.67	4084.64	4160.53	58
59	3579.30	3649.24	3719.88	3791.38	3863.67	3936.88	4010.91	4085.90	4161.80	59

RAILROAD CURVE TABLES.

′	72°	73°	74°	75°	76°	77°	78°	79°	80°	′
0	4163.07	4239.97	4317.84	4396.74	4476.73	4557.81	4640.04	4723.41	4808.04	0
1	4164.35	4241.26	4319.15	4398.07	4478.08	4559.18	4641.43	4724.82	4809.47	1
2	4165.63	4242.56	4320.46	4399.40	4479.42	4560.54	4642.81	4726.22	4810.89	2
3	4166.90	4243.85	4321.77	4400.73	4480.77	4561.91	4644.20	4727.63	4812.32	3
4	4168.18	4245.14	4323.08	4402.06	4482.12	4563.27	4645.58	4729.03	4813.74	4
5	4169.46	4246.44	4324.39	4403.39	4483.46	4564.64	4646.97	4730.44	4815.17	5
6	4170.74	4247.73	4325.70	4404.71	4484.81	4566.01	4648.35	4731.85	4816.59	6
7	4172.02	4249.02	4327.01	4406.04	4486.16	4567.37	4649.74	4733.25	4818.02	7
8	4173.29	4250.31	4328.32	4407.37	4487.51	4568.74	4651.12	4734.66	4819.44	8
9	4174.57	4251.61	4329.63	4408.70	4488.85	4570.10	4652.50	4736.06	4820.87	9
10	4175.85	4252.90	4330.94	4410.03	4490.20	4571.47	4653.89	4737.47	4822.29	10
11	4177.13	4254.19	4332.25	4411.36	4491.55	4572.83	4655.27	4738.87	4823.72	11
12	4178.41	4255.49	4333.56	4412.69	4492.89	4574.20	4656.66	4740.28	4825.14	12
13	4179.68	4256.78	4334.87	4414.02	4494.24	4575.56	4658.04	4741.68	4826.57	13
14	4180.96	4258.07	4336.18	4415.35	4495.59	4576.93	4659.43	4743.09	4827.99	14
15	4182.24	4259.36	4337.49	4416.68	4496.93	4578.30	4660.81	4744.50	4829.42	15
16	4183.52	4260.66	4338.80	4418.01	4498.28	4579.66	4662.20	4745.90	4830.84	16
17	4184.80	4261.95	4340.11	4419.34	4499.63	4581.03	4663.58	4747.31	4832.27	17
18	4186.07	4263.24	4341.42	4420.67	4500.98	4582.39	4664.97	4748.71	4833.69	18
19	4187.35	4264.54	4342.73	4422.00	4502.32	4583.76	4666.35	4750.12	4835.12	19
20	4188.63	4265.83	4344.05	4423.33	4503.67	4585.12	4667.73	4751.52	4836.54	20
21	4189.91	4267.12	4345.36	4424.65	4505.01	4586.49	4669.12	4752.93	4837.97	21
22	4191.19	4268.42	4346.67	4425.98	4506.35	4587.86	4670.50	4754.34	4839.39	22
23	4192.46	4269.71	4347.98	4427.31	4507.70	4589.22	4671.89	4755.74	4840.82	23
24	4193.74	4271.00	4349.29	4428.64	4509.05	4590.59	4673.27	4757.15	4842.24	24
25	4195.02	4272.29	4350.60	4429.97	4510.39	4591.95	4674.66	4758.55	4843.67	25
26	4196.30	4273.59	4351.91	4431.30	4511.74	4593.32	4676.04	4759.96	4845.09	26
27	4197.57	4274.88	4353.22	4432.63	4513.09	4594.69	4677.43	4761.37	4846.52	27
28	4198.85	4276.17	4354.53	4433.96	4514.44	4596.05	4678.81	4762.77	4847.94	28
29	4200.13	4277.47	4355.84	4435.29	4515.78	4597.42	4680.20	4764.18	4849.37	29
30	4201.41	4278.76	4357.15	4436.62	4517.13	4598.78	4681.58	4765.58	4850.79	30
31	4202.70	4280.06	4358.47	4437.96	4518.49	4600.15	4682.97	4766.99	4852.23	31
32	4203.98	4281.36	4359.79	4439.29	4519.84	4601.53	4684.37	4768.41	4853.66	32
33	4205.27	4282.67	4361.11	4440.63	4521.20	4602.91	4685.76	4769.83	4855.10	33
34	4206.55	4283.97	4362.43	4441.97	4522.55	4604.28	4687.16	4771.24	4856.53	34
35	4207.84	4285.27	4363.75	4443.30	4523.91	4605.66	4688.55	4772.66	4857.97	35
36	4209.12	4286.58	4365.07	4444.64	4525.27	4607.03	4689.94	4774.07	4859.41	36
37	4210.41	4287.88	4366.39	4445.98	4526.62	4608.41	4691.34	4775.49	4860.84	37
38	4211.69	4289.18	4367.71	4447.32	4527.98	4609.78	4692.73	4776.90	4862.28	38
39	4212.98	4290.48	4369.03	4448.65	4529.33	4611.16	4694.13	4778.32	4863.71	39
40	4214.26	4291.79	4370.35	4449.99	4530.69	4612.53	4695.52	4779.73	4865.15	40
41	4215.55	4293.09	4371.67	4451.33	4532.05	4613.91	4696.92	4781.15	4866.59	41
42	4216.83	4294.39	4372.99	4452.66	4533.40	4615.28	4698.31	4782.56	4868.03	42
43	4218.12	4295.69	4374.31	4454.00	4534.76	4616.66	4699.70	4783.98	4869.46	43
44	4219.40	4297.00	4375.63	4455.34	4536.11	4618.03	4701.10	4785.39	4870.90	44
45	4220.69	4298.30	4376.94	4456.67	4537.47	4619.41	4702.49	4786.81	4872.33	45
46	4221.98	4299.60	4378.26	4458.01	4538.83	4620.78	4703.89	4788.22	4873.77	46
47	4223.26	4300.91	4379.58	4459.35	4540.18	4622.16	4705.28	4789.64	4875.21	47
48	4224.55	4302.21	4380.90	4460.69	4541.54	4623.53	4706.67	4791.05	4876.64	48
49	4225.83	4303.51	4382.22	4462.02	4542.89	4624.91	4708.07	4792.47	4878.08	49
50	4227.12	4304.81	4383.54	4463.36	4544.25	4626.29	4709.47	4793.89	4879.52	50
51	4228.40	4306.12	4384.86	4464.70	4545.61	4627.66	4710 86	4795.30	4880.95	51
52	4229.69	4307.42	4386.18	4466.03	4546.96	4629.04	4712.25	4796.72	4882.39	52
53	4230.97	4308.72	4387.50	4467.37	4548.32	4630.41	4713.65	4798.13	4883.83	53
54	4232.26	4310.02	4388.82	4468.71	4549.67	4631.79	4715.04	4799.55	4885.26	54
55	4233.54	4311.33	4390.14	4470.04	4551.03	4633.16	4716.44	4800.96	4886.70	55
56	4234.83	4312.63	4391.46	4471.38	4552.39	4634.54	4717.83	4802.38	4888.13	56
57	4236.11	4313.93	4392.78	4472.72	4553.74	4635.91	4719.22	4803.79	4889.57	57
58	4237.40	4315.23	4394.10	4474.06	4555.10	4637.29	4720.62	4805.21	4891.00	58
59	4238.68	4316.54	4395.42	4475.39	4556.45	4638.66	4722.01	4806.62	4892.44	59

RAILROAD CURVE TABLES.

′	81°	82°	83°	84°	85°	86°	87°	88°	89°	′
0	4893 88	4980.97	5069.44	5159.29	5250.57	5343.28	5437.54	5533.35	5630.81	0
1	4895.33	4982.44	5070.93	5160.80	5252.11	5344.84	5439.13	5534.97	5632.46	1
2	4896.77	4983 91	5072.42	5162.32	5253.65	5346.41	5440.72	5536 59	5634.10	2
3	4898.22	4985.38	5073.92	5163.83	5255.19	5347.97	5442.31	5538.20	5635.75	3
4	4899.66	4986.85	5075 41	5165.35	5256.73	5349.54	5443.90	5539.82	5637.39	4
5	4901.11	4988.32	5076.90	5166.86	5258.27	5351 10	5445.50	5541.44	5639.04	5
6	4902.56	4989.78	5078.39	5168.38	5259.81	5352.67	5447.09	5543.06	5640.69	6
7	4904.00	4991.25	5079.88	5169.89	5261.35	5354.23	5448.68	5544.68	5642.33	7
8	4905.45	4992.72	5081 38	5171.41	5262.88	5355.79	5450.27	5546 29	5643.98	8
9	4906.89	4994.19	5082.87	5172.92	5264.42	5357.36	5451.86	5547.91	5645 63	9
10	4908.34	4995.66	5084.36	5174.44	5265.96	5358.92	5453.45	5549.53	5647.27	10
11	4909.78	4997.13	5085.85	5175.95	5267.50	5360.49	5455.04	5551.14	5648.92	11
12	4911.23	4998.60	5087.34	5177.47	5269.04	5362 05	5456.63	5552.76	5650.57	12
13	4912.68	5000.07	5088.84	5178.98	5270.58	5363.62	5458.22	5554.38	5652.21	13
14	4914.12	5001.54	5090.33	5180.50	5272.12	5365.18	5459.81	5556.00	5653.86	14
15	4915.57	5003.01	5091.82	5182.01	5273.66	5366.74	5461.41	5557.62	5655.50	15
16	4917.01	5004.47	5093.31	5183.53	5275.20	5368.31	5463.00	5559.24	5657.15	16
17	4918.46	5005.94	5094.80	5185.04	5276.74	5369.87	5464.59	5560.85	5658.80	17
18	4919.91	5007.41	5096.30	5186.56	5278.28	5371.44	5466.18	5562 47	5660.44	18
19	4921.35	5008.88	5097.79	5188.07	5279.82	5373.00	5467.77	5564.09	5662.09	19
20	4922.79	5010.35	5099.28	5189.58	5281.36	5374.57	5469.36	5565.70	5663.74	20
21	4924.24	5011.82	5100.77	5191.10	5282.90	5376.13	5470.95	5567.32	5665.38	21
22	4925.69	5013.29	5102.26	5192.61	5284.44	5377.69	5472.54	5568.94	5667.03	22
23	4927.13	5014.76	5103.76	5194.13	5285.97	5379.26	5474.13	5570.56	5668.67	23
24	4928.58	5016.23	5105.25	5195.64	5287.51	5380.82	5475.72	5572.18	5670.32	24
25	4930.02	5017.69	5106.74	5197.16	5289.05	5382.39	5477.32	5573.79	5671.97	25
26	4931.47	5019.16	5108.23	5198.67	5290.59	5383.95	5478.91	5575.41	5673.61	26
27	4932.92	5020.63	5109.72	5200.19	5292.13	5385.51	5480.50	5577.03	5675.26	27
28	4934.36	5022.10	5111.22	5201.70	5293.67	5387.08	5482.09	5578.65	5676.91	28
29	4935.81	5023.57	5112.71	5203.22	5295.21	5388.64	5483.68	5580.27	5678.55	29
30	4937.25	5025.04	5114.20	5204.73	5296.75	5390.21	5485.27	5581.88	5680.20	30
31	4938 71	5026 52	5115.70	5206.26	5298.30	5391.79	5486.87	5583.51	5681.86	31
32	4940.16	5028.00	5117.21	5207.79	5299.85	5393.37	5488.48	5585.14	5683.52	32
33	4941.62	5029.48	5118.71	5209.31	5301.40	5394.94	5490.08	5586.77	5685.18	33
34	4943.08	5030.96	5120.21	5210.84	5302.95	5396.52	5491 68	5588.40	5686.84	34
35	4944 54	5032 44	5121.72	5212.37	5304.51	5398.10	5493.29	5590.04	5688.50	35
36	4945.99	5033.92	5123.22	5213.90	5306.06	5399.68	5494.89	5591.67	5690.16	36
37	4947.45	5035.40	5124.72	5215.43	5307.61	5401.25	5496.49	5593.30	5691.82	37
38	4948.91	5036.88	5126.22	5216 95	5309.16	5402.83	5498.09	5594.93	5693.48	38
39	4950.36	5038 36	5127.73	5218.48	5310.71	5404.41	5499.70	5596.56	5695.14	39
40	4951.82	5039.84	5129.23	5220.01	5312.26	5405.99	5501.30	5598.19	5696.80	40
41	4953.28	5041.32	5130.73	5221.54	5313.81	5407.56	5502.90	5599.82	5698.46	41
42	4954.74	5042.80	5132.24	5223 07	5315.36	5409.14	5504.50	5601.45	5700.12	42
43	4956.19	5044.28	5133 74	5224.59	5316.91	5410.72	5506.11	5603.08	5701.78	43
44	4957.65	5045.76	5135.24	5226.12	5318.46	5412.30	5507.71	5604.71	5703.44	44
45	4959.11	5047.24	5136.75	5227.65	5320.02	5413.88	5509.31	5606.35	5705.10	45
46	4960.57	5048.72	5138.25	5229.18	5321 57	5415.45	5510.91	5607.98	5706.76	46
47	4962.02	5050 20	5139.75	5230.71	5323.12	5417.03	5512.52	5609.61	5708.42	47
48	4963.48	5051.68	5141.25	5232.23	5324.67	5418.61	5514.12	5611.24	5710.08	48
49	4964.94	5053.16	5142.76	5233.76	5326.22	5420.19	5515.72	5612.87	5711.74	49
50	4966.40	5054.64	5144 26	5235.29	5327.77	5421.76	5517 32	5614.50	5713.40	50
51	4967.85	5056.12	5145.76	5236.82	5329 32	5423.34	5518.93	5616.13	5715.06	51
52	4979.31	5057.60	5147.27	5238.35	5330.87	5424.92	5520.53	5617.76	5716.72	52
53	4970.77	5059.08	5148.77	5239.87	5332.42	5426.50	5522.13	5619.39	5718 38	53
54	4972.22	5060.56	5150.27	5241.40	5333.97	5428.07	5523.74	5621.02	5720.04	54
55	4973.68	5062.04	5151.77	5242.93	5335.53	5429.65	5525.34	5622.66	5721.70	55
56	4975.14	5063.52	5153.28	5244.46	5337.08	5431.23	5526.94	5624.29	5723.36	56
57	4976.60	5065.00	5154.78	5245.99	5338.63	5432.81	5528.54	5625.92	5725.02	57
58	4978.05	5066.48	5156.28	5247.51	5340.18	5434.39	5530.15	5627.55	5726.68	58
59	4979.51	5067.96	5157.79	5249.04	5341.73	5435.96	5531.75	5629.18	5728.34	59

TABLE OF MINUTES WITH CORRESPONDING DECIMALS.				TABLE OF SECONDS WITH CORRESPONDING DECIMALS.			
M.	D.	M.	D.	S.	D.	S.	D.
′	°	′	°	″	″	″	°
1	0.0166	31	0.5167	1	0.0002778	31	0.0086111
2	0.0333	32	0.5333	2	0.0005556	32	0.0088888
3	0.0500	33	0.5500	3	0.0008333	33	9.0091666
4	0.0667	34	0.5667	4	0.0011111	34	0.0094444
5	0.0833	35	0.5833	5	0.0013888	35	0.0097222
6	0.1000	36	0.6000	6	0.0016666	36	0.0100000
7	0.1167	37	0.6167	7	0.0019444	37	0.0102777
8	0.1333	38	0.6333	8	0.0022222	38	0.0105555
9	0.1500	39	0.6500	9	0.0025000	39	0.0108333
10	0.1667	40	0.6667	10	0.0027777	40	0.0111111
11	0.1833	41	0.6833	11	0.0030555	41	0.0113888
12	0.2000	42	0.7000	12	0.0033333	42	0.0116666
13	0.2167	43	0.7167	13	0.0036111	43	0.0119444
14	0.2333	44	0.7333	14	0.0038888	44	0.0122222
15	0.2500	45	0.7500	15	0.0041666	45	0.0125000
16	0.2667	46	0.7667	16	0.0044444	46	0.0127777
17	0.2833	47	0.7833	17	0.0047722	47	0.0130555
18	0.3000	48	0.8000	18	0.0050000	48	0.0133333
19	0.3167	49	0.8167	19	0.0052777	49	0.0136111
20	0.3333	50	0.8333	20	0.0055555	50	0.0138888
21	0.3500	51	0.8500	21	0.0058333	51	0.0141666
22	0.3667	52	0.8667	22	0.0061111	52	0.0144444
23	0.3833	53	0.8833	23	0.0063888	53	0.0147222
24	0.4000	54	0.9000	24	0.0066666	54	0.0150000
25	0.4167	55	0.9167	25	0.0069444	55	0.0152777
26	0.4333	56	0.9333	26	0.0072222	56	0.0155555
27	0.4500	57	0.9500	27	0.0075000	57	0.0158333
28	0.4667	58	0.9667	28	0.0077777	58	0.0161111
29	0.4833	59	0.9833	29	0.0080555	59	0.0163888
30	0.5000	60	1.0000	30	0.0083333	60	0.0166666

RAILROAD CURVE TABLE.

The following Table shows the distance from the point of intersection of the Tangent lines to the beginning of one degree curves, for each 30 feet, the angle of deflection (=angle at centre) being known.

I. = The given angle of deflection.

II. = The sought for distance.

III. = Difference for intermediate angles.

RAILROAD CURVE TABLE.

I	II	III	I	II	III	I	II	III
0° 0′	25.00	25.0	30° 30′	1562.17	26.8	60° 30′	3341.62	33.4
1	50.02	25.0	31	1589.04	26.9	61	3375.20	33.6
1 30	75.01	25.0	31 30	1616.03	27.0	61 30	3408.95	33.8
2	99.99	25.0	32	1643.08	27.0	62	3442.93	34.0
2 30	125.03	25.0	32 30	1670.12	27.0	62 30	3477.02	34.1
3	150.07	25.0	33	1697.28	27.2	63	3511.34	34 3
3 30	175.05	25.0	33 30	1724.56	27.3	63 30	3545.78	34.4
4	200.09	25.0	34	1751.83	27.3	64	3580.45	34.7
4 30	225.13	25.0	34 30	1779.22	27.4	64 30	3615.34	34.9
5	250.17	25.0	35	1806.67	27.4	65	3650.41	35.1
5 30	275.21	25.0	35 30	1834.17	27.5	65 30	3685 65	35.2
6	300.30	25.0	36	1861.79	27.6	66	3721.06	35.4
6 30	325.35	25.0	36 30	1889.47	27.7	66 30	3756.70	35 6
7	350.44	25.1	37	1917.26	27.8	67	3792.57	35 9
7 30	375.54	25.1	37 30	1945.05	27.8	67 30	3828.61	36.0
8	400.70	25.1	38	1973.01	27.9	68	3864.88	36.3
8 30	425.79	25.1	38 30	2001.03	28.0	68 30	3901.38	36.5
9	450.95	25.1	39	2029.11	28.1	69	3938.11	36.7
9 30	476.10	25.1	39 30	2057.30	28.2	69 30	3975.01	36.9
10	501.32	25.2	40	2085.55	28.3	70	4012.15	37.1
10 30	526.53	25.2	40 30	2113.91	28.4	70 30	4019.56	37.4
11	551.74	25.2	41	2142.33	28.4	71	4087.15	37.6
11 30	576.95	25.2	41 30	2170.92	28.6	71 30	4124.97	37.8
12	602.22	25.3	42	2199.52	28.6	72	4163.07	38.1
12 30	627.55	25.3	42 30	2228.28	28.8	72 30	4201.41	38.3
13	652.87	25.3	43	2257.10	28.8	73	4239.97	38.6
13 30	678.20	25.3	43 30	2286.04	28.9	73 30	4278 76	38.8
14	703.53	25.3	44	2315.09	29.0	74	4317.84	38.9
14 30	728.97	25.4	44 30	2344.20	29.1	74 30	4357.15	39 3
15	754.35	25.4	45	2373.42	29.2	75	4396.74	39.6
15 30	779.79	25.4	45 30	2402.76	29.3	75 30	4436.62	39.9
16	805.29	25.5	46	2432.21	29.4	76	4476.73	40.1
16 30	830.79	25.5	46 30	2461.78	29.6	76 30	4517.13	40.4
17	856.35	25.5	47	2491 46	29.7	77	4557.81	40.7
17 30	881.90	25.5	47 30	2521.26	29.8	77 30	4598.78	41.0
18	907.52	25.6	48	2551.11	29.8	78	4640.04	41.3
18 30	933.18	25.6	48 30	2581.13	30.0	78 30	4681.58	41 5
19	958.86	25.7	49	2611.27	30.1	79	4723.41	41.8
19 30	984.58	25.7	49 30	2641.53	30.3	79 30	4765.58	42.2
20	1010.37	25.8	50	2671.90	30.4	80	4808.04	42.5
20 30	1036.15	25.8	50 30	2702.44	30.5	80 30	4850.79	42.7
21	1062.00	25.8	51	2733.04	30.6	81	4893.88	43.1
21 30	1089.90	25.9	51 30	2763.81	30.8	81 30	4937.25	43.3
22	1113.80	25.9	52	2794.69	30.9	82	4980.97	43.7
22 30	1139.75	25.9	52 30	2825.69	31.0	82 30	5025.04	44.1
23	1165.76	26.0	53	2856.86	31.2	83	5069.44	44.4
23 30	1191.84	26.1	53 30	2888.15	31.3	83 30	5114.20	44.8
24	1217.96	26.1	54	2919.55	31.4	84	5159.29	45.1
24 30	1244.10	26.1	54 30	2951.12	31.6	84 30	5204.73	45.4
25	1270.28	26.2	55	2982.81	31.7	85	5250.57	45.8
25 30	1296.58	26.3	55 30	3014.67	31.9	85 30	5296.75	46.2
26	1322.88	26.3	56	3046.64	32.0	86	5343.28	46.5
26 30	1349.24	26.4	56 30	3078.79	32.2	86 30	5390.21	46.9
27	1375.65	26.4	57	3111.10	32.3	87	5437.54	47.3
27 30	1402.10	26.4	57 30	3143.53	32.4	87 30	5485.27	47.7
28	1428.65	26.5	58	3176.14	32.6	88	5533.35	48.1
28 30	1455.25	26.6	58 30	3208.91	32.8	88 30	5581.88	48.5
29	1481.89	26.6	59	3241.86	32.9	89	5630.81	48.9
29 30	1508.59	26.7	59 30	3274.92	33.1	89 30	5680.20	49.4
30	1535.30	26.7	60	3308.21	33.3	90	5730.00	49.8

RAILROAD CURVES.

THE FOLLOWING TABLE SHOWS THE METHOD OF

KEEPING THE FIELD NOTES

OF A SURVEY, FROM WHICH THE CENTER LINE IS LAID ON THE MAP

From station.	To station.	Length of tangents in feet.	Length of curves in feet	Angle at intersection of tangents or angle at centre.	Course of tangent, and degree and direction of curves.	Radius of curves in feet.	No. of ft. from intersection of tangents to begng. of curve.
.....	.....	.....	.....	Tangent	S 19° 21′ E		
0.	2.		200.	7° 24′	3° 42′ L	1548.65	100.14
2.	26.		2400.	24° 00′	1° 00′ R	5730.	1217.96
26.	43.556	1755.60		Tangent	S 2° 45′ E		
43.556	61.681		1812.5	36° 15′	2° 00′ R	2865.	937.82
61.681	93.650	3196.90		Tangent	S 33° 30′ W		
93.650	102.517		886.7	13° 18′	1° 30′ L	3820.	445.37
102 517	143.90	4138.30		Tangent	S 20° 12′ W		
143.90	155.766		1186.66	23° 44′	2° 00′ L	2865.	602.02
155.766	170.43	1466.40		Tangent	S 3° 32′ E		
170.43	181.296		1086.66	21° 44′	2° 00′ R	2865.	550.00
181.296	184.506	321.00		Tangent	S 18° 12′ W		
184.506	193.195		868.89	13° 02′	1° 30′ R	3820.	436.37
193.195	213.064	1986.9		Tangent	S 31° 14′ W		
213.064	220.908		784.44	11° 46′	1° 30′ L	3820.	393.61
220.908	230.546	963.8		Tangent	S 19° 28′ W		
230.546	242.496		1195.00	23° 54′	2° 00′ R	2865.	606.37
242.496	252.356	986 00		Tangent	S 43° 22′ W		
252.356	263.756		1140.00	17° 06′	1° 30′ L	3820.	574.30
263.756	266.02	226.40		Tangent	S 26° 16′ W		
266.02	268.02		200.00	3°	1° 30′ L	3820.	100.05
268.02	277.21		918.89	27° 34′	3° L	1910.	468.55
277.21	279.21		200.00	3° 00′	1° 30′ L	3820.	100.05
279.21	289.011	980.1		Tangent	S 7° 18′ E		
289.011	291.011		200.00	3° 00′	1° 30′ R	3820.	100.05
291.011	301.422		1041.10	31° 14′	3° 00′ R	1910.	534.88
301.422	303.00		157.80	2° 22′	1° 30′ R	3820.	78.90
303.00	321.00	1800.		Tangent	S 29° 18′ W		
321.00	334.00		1300.	26°	2° L	2865.	661.44
334.	338.71	471.00		Tangent	S 3° 18′ W		
338.71	347.15		844.16	16° 53′	2° 00′ R	2865.	425.19
347.15	364.00	1685.00		Tangent	S 20° 11′ W		
364.	376.633		1263.33	37° 54′	3° "	1910.	655.80
376.633	389.53	389.70		Tangent	S 58° 05′ W		
380.53	392.38		1185.	23° 42′	2° R	2865.	601.14
392.38	402.92	1054.00		Tangent	S 81° 47′ W		
402.92	404.92		200.	3° 00′	1° 30′ L	3820.	100.05
404.92	418.198		1327.77	39° 50′	3° 00′ L	1910.	632.04
418.198	420.198	200.		Tangent	S 38° 57′ W		
420.198	441.002		2080.41	83° 13′	4° L	1432.	1272.21
441.002	442.582		158.	4° 00′	2° 32′ L	2261.87	79.99
442.582	449.	641.8		Tangent	S 48° 16′ E		
		22.262.90	22.637.31				

APPLICATION OF THE PRISMOIDAL FORMULA

IN DETERMINING THE QUANTITIES OF RAILROADS AND CANAL EXCAVATIONS AND EMBANKMENTS.

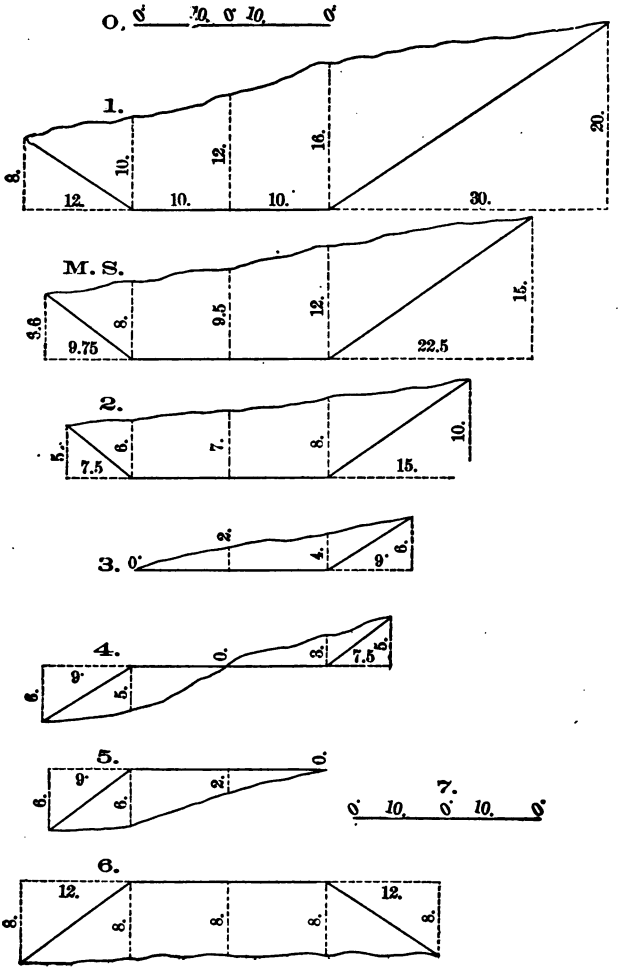
In order to obtain the mean area from transverse sections, construct from the average cuttings and average horizontal distances of the slopes of the end section, a middle section; and add to four times the area of this section the area of the end sections, and take one-sixth of the product for the mean area.

The following diagrams show most of the figures which occur in taking cross sections of railroads, and serve to illustrate the application of the formula. In practice, however, intermediate sections would be taken between station 0 and station 1, and at such other points as any sudden or material change in the surface would seem to require.

The cuttings and horizontal distances from the centre to the termination of the slopes, are set down in tabular form. The notes of the middle section may at convenience be interlined in the space between the notes of the end sections. From this form the factors for the areas are made without resorting to diagrams.—*Page* 34.

*It will be seen by inspecting the diagrams that the embankment between stations 3 and 4 assumes the shape of a pyramid, and hence one-third of the area of the embankment set opposite station 4, should be multiplied by the distance between stations 3 and 4 to obtain the quantity. Between stations 4 and 5 the excavation assumes the same form, and should also be calculated as a pyramid; or construct the middle section as before described, and calculate the distance from the centre to the point where the surface and the grade intersect; and make out the factors accordingly.

Having obtained the mean areas, proceed as hereinafter described to ascertain the cubic yards.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3. 0.
2.
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9.
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4.
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7.5
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7.
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10.
0
10.
0
6.
8.
12.
8.
8.
8.
12.
8.

FIELD NOTES FOR TRANSVERSE SECTIONS.

Stations.	Distances in feet.	Left slope stake +or—	Distance from center.	Angle +or—	Center +or—	Angle +or—	Distance from center.	Right slope stake +or—	Area of Excavation.	Area of Embankment.	Mean area of Excavation.	Mean area of Embankment.	Cubic yards of Excavation.	Cubic yards of Embankment.
0	0	0	10.	0	0	0	10.	0	0					
M. S.		+4.	16.	+5.	+6.	+8.	25.	+10.	200.					
1	100	+8.	22.	+10.	+12.	+16.	40.	+20.	550.		225.		833.33	
M. S.		+6.5	19.75	+8.	+9.5	+12.	32.5	+15.	369.					
2	100	+5.	17.5	+6.	+7.	+8.	25.	+10.	222.5		374.75		1387.96	
M. S.		+2.5	13.75	+3.	+4.5	+6.	22.	+8.	131.62					
3	100	0	10.	0	+2.	+4.	19.	+6.	58.		134.5 *		498.14	
M. S.		—3.	14.5	—2.5	+1.	+3.5	18.25	+5.5	38.34					
4	100	—6.	19.	—5.	—0	+3.	17.5	+5.	26.25	47.5	39.60	15.83	146.66	58.62
M. S.		—6.	19.	—5.5	—1.	+1.5	13.75	+2.5		59.8				
5	100	—6.	19.	—6.	—2.	0	10.	0		77.	8.75	60.61	32.40	224.48
M. S.		—7.	20.5	—7.	—5.	—4.	16.	—4.		153.75				
6	100	—8.	22.	—8.	—8.	—8.	22.	—8.		256.		158.0		585.18
M. S.		—4.	16.	—4.	—4.	—4.	16.	—4.		104.				
7	100	0	10.	0	0	0	10.	0		0		112.0		414.81

FACTORS.

EXCAVATION.

STATION 0. AREAS.

0.——0.——0. = 000.

MIDDLE SECTION.

16. × 5. = 80.
20. × 6. =120.
25. × 8. =200.

400.÷2.=200.

STATION 1.

22. × 10. =220.
20. × 12. =240.
40. × 16. =640.

1100.÷2.=550.

MIDDLE SECTION.

19.75 × 8. =158.
9.50 × 20. =190.
32.50 × 12. =390.

738.÷2.=369.

STATION 2.

17.50 × 6. =105.
20. × 7. =140.
25. × 8. =200.

445.÷2.=222.5.

MIDDLE SECTION.

13.75 × 3. = 41.25
20. × 4.5= 90.
22. × 6. =132.

263.25.÷2.=131.62.

STATION 3.

20. × 2. = 40.
19. × 4. = 76.

116.÷2.= 58.

MIDDLE SECTION.

12.8 × 1. = 12.80
18.25 × 3.5= 63.88

76.68.÷2.= 38.34.

STATION 4.

17.5 × 3. = 52.5 ÷2.= 26.25.

STATION 5.

——0.

EMBANKMENT.

STATION 4. AREAS.

19. × 5. = 95.÷2.= 47.5.

MIDDLE SECTION.

19. × 5.5=104.5
15. × 1. = 15.

119.5÷2.= 59.75.

STATION 5.

19. × 6. =114.
20. × 2. = 40.

154.÷2.= 77.

MIDDLE SECTION.

20.5 × 7. =143.5
20. × 5. =100.
16. × 4. = 64.

307.5÷2.=153.75.

STATION 6.

22. × 8. =176.
20. × 8. =160.
22. × 8. =176.

512.÷2.=256.

MIDDLE SECTION.

16. × 4. = 64.
20. × 4. = 80.
16. × 4. = 64.

208.÷2=104.

STATION 7.

0.——0.——0.

The cubic yards between station 0 and station 1 according to the method of adding the end areas and taking one-half for the mean area - - - - = 1018.51 c. yds.
By 2d (or Prismoidal method)= 833.33 " } c. yds. 185.18

" 1st	method	between	station	1 and 2 =	1430.55	"	42.59
" 2d	"	"	"	1 and 2	1387.96	"	
" 1st	"	"	"	2 and 3	519.44	"	21.30
" 2d	"	"	"	2 and 3	498.14	"	
" 1st	"	"	"	3 and 4	156.01	"	9.35
" 2d	"	"	"	3 and 4	146.66	"	
" 1st	"	"	"	4 and 5	48.59	"	16.19
" 2d	"	"	"	4 and 5	32.40	"	

Error on 500 lineal feet of excavation - - =274.61

There are other methods which approximate nearer than the averaging method. For instance, taking $\frac{1}{2}\frac{1}{4}$ths of the difference between the end areas, (or the difference 0×0.46) and adding it to the lesser end area for the mean.

This method approximates nearer the true quantity. The principal discrepancy occurs where the embankment assumes the wedge or pryamidal form.—

By 3d	method	between	station	0 and 1	937.03	+	103.70
" 2d	"	(or Prismoidal)		0 and 1	833.33		
" 3d	"	between	station	1 and 2	1382.03	—	5.93
" 2d	"	"	"	1 and 2	1387.96		
" 3d	"	"	"	2 and 3	495.08	—	3.06
" 2d	"	"	"	2 and 3	498.14		
" 3d	"	"	"	3 and 4	151.31	—	4.65
" 2d	"	"	"	3 and 4	146.66		
" 3d	"	"	"	4 and 5	44.72	+	12.32
" 2d	"	"	"	4 and 5	32.40		

Error on 500 lineal feet of excavation - 102.38

Another method is to multiply $\frac{1}{8}$ of the distance between transverse sections, by the sum of the end areas, added to four times half their sum; and dividing by 27 for the cubic yards.

The results are the same as by the first method except between stations 0 and 1.

EXPLANATION OF THE FOLLOWING TABLES.

The tables are calculated for a distance of 100 feet between transverse sections.

In the left hand column are given the areas in feet. To obtain the cubic yards for areas, without decimals, look in the second column under the head of 0, and opposite the given area, find the cubic yards.

EXAMPLE.—Required the number of cubic yards for an area of 190 feet. In the second column, under the head of 0, and opposite 190 in the first column, find 703.70 cubic yards.

To obtain the cubic yards for a less distance than 100 feet, multiply the cubic yards found in the tables by the given distance, and point off the fractional parts of 100 feet.

If the area has decimal parts, pass the eye to the right, opposite the area of the whole number, and under the head of such decimal will be found the number of yards.

EXAMPLE.—Required the cubic yards for an area of 105.4 feet. In the sixth column, under the head of 40, and opposite 105 in the first column, are given 390.37 cubic yards.

If the yards for an area greater than 354.90, and not exceeding 3549 feet, are required, the decimal point of the area given in the tables, and that of the cubic yards, being removed one figure to the right, will give the required yards. If there are decimal parts, add the cubic yards found opposite 0 in the first column, under the head of such decimal.

EXAMPLE.—Required the cubic yards for an area of 1975 feet; remove the decimal point one figure to the left, and find the yards for an area of 197.5 feet = 731.48, then remove the decimal point one figure to the right and you have 7314.8 cubic yards. If there is a decimal, add the cubic yards found for such decimal.

Or, to obtain the cubic yards for an area exceeding 3549 feet, take one half of the area, and seek the corresponding yards in tables and multiply the same by 2.

EXCAVATION AND EMBANKMENT TABLES.

	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
0	0.00	0.37	0.74	1.11	1.48	1.85	2.22	2.59	2.96	3.33
1	3.70	4.07	4.45	4.81	5.19	5.56	5.93	6.30	6.67	7.04
2	7.41	7.78	8.15	8.52	8.89	9.26	9.63	10.00	10.37	10.74
3	11.11	11.48	11.85	12.22	12.59	12.96	13.33	13.70	14.07	14.44
4	14.82	15.19	15.56	15.93	16.30	16.67	17.04	17.41	17.78	18.15
5	18.52	18.89	19.26	19.63	20.00	20.37	20.74	21.11	21.48	21.85
6	22.22	22.59	22.96	23.33	23.70	24.07	24.44	24.82	25.19	25.56
7	25.93	26.30	26.67	27.04	27.41	27.78	28.15	28.52	28.89	29.26
8	29.63	30.00	30.37	30.74	31.11	31.48	31.85	32.22	32.59	32.96
9	33.33	33.70	34.07	34.44	34.82	35.19	35.56	35.93	36.30	36.67
10	37.04	37.41	37.78	38.15	38.52	38.89	39.26	39.63	40.00	40.37
11	40 74	41.11	41.48	41.85	42.22	42.59	42.96	43.33	43.70	44.07
12	44.44	44.82	45.19	45.56	45.93	46.30	46.67	47.04	47.41	47.78
13	48.15	48.52	48.89	49.26	49.63	50.00	50.37	50.74	51.11	51.48
14	51.85	52.22	52.59	52.96	53.33	53.70	54.07	54.44	54.82	55.19
15	55.56	55.93	56.30	56.67	57.04	57.41	57.78	58.15	58.52	58.89
16	59.26	59.63	60.00	60.37	60.74	61.11	61.48	61.85	62.22	62.59
17	62.96	63.33	63.70	64.07	64.44	64.82	65.19	65.56	65.93	66.30
18	66.67	67.04	67.41	67.78	68.15	68.52	68.89	69.26	69.63	70.00
19	70.37	70.74	71.11	71.48	71.85	72.22	72.59	72.96	73.33	73 70
20	74.07	74.44	74.82	75.19	75.56	75.93	76.30	76.67	77.04	77.41
21	77.78	78.15	78.52	78.89	79.26	79.63	80.00	80.37	80.74	81.11
22	81.48	81.85	82.22	82.59	82.96	83.33	83.70	84.07	84.44	84.82
23	85.19	85.56	85.93	86.30	86.67	87.04	87.41	87.78	88.15	88.52
24	88.89	89.26	89.63	90.00	90.37	90.74	91.11	91.48	91.85	92.22
25	92.59	92.96	93.33	93.70	94.07	94.44	94.82	95.19	95.56	95.93
26	96.30	96.67	97.04	97.41	97.78	98.15	98.52	98.89	99.26	99 63
27	100.00	100.37	100.74	101.11	101.48	101.85	102.22	102.59	102.96	103.33
28	103.70	104.07	104.44	104.82	105.19	105.56	105.93	106.30	106.67	107.04
29	107.41	107.78	108.15	108.52	108.89	109.26	109.63	110.00	110.37	110.74
30	111.11	111.48	111.85	112.22	112.59	112.96	113.33	113.70	114.07	114.44
31	114.81	115.18	115 56	115.92	116.29	116.67	117.03	117.40	117.77	118.15
32	118.52	118.89	119.26	119.63	120.00	120.37	120.74	121.11	121.48	121.85
33	122.22	122.59	122.96	123.33	123.70	124.07	124.44	124.81	125.18	125.55
34	125.92	126.30	126.66	127.03	127.40	127.77	128.14	128.51	128.88	129.26
35	129.63	130.00	130 37	130.74	131.11	131.48	131.85	132.22	132.59	132.96
36	133.33	133.70	134.07	134.44	134.81	135.18	135.55	135.92	136.29	136.67
37	137.04	137.41	137.78	138.15	138.52	138.89	139.26	139.63	140.00	140.37
38	140.74	141.11	141.48	141.85	142.22	142.59	142.96	143.33	143.70	144.07
39	144.44	144.81	145.18	145.55	145.92	146.29	146.66	147.03	147.40	147.78
40	148.15	148.52	148.89	149.26	149.63	150.00	150.37	150.74	151.11	151.48
41	151.85	152.22	152.59	152.96	153.33	153.70	154.07	154.44	154.81	155.18
42	155.55	155.92	156.29	156.66	157.03	157.40	157.77	158.14	158.51	158.89
43	159.26	159.63	160.00	160.37	160.74	161.11	161.48	161.85	162.22	162.59
44	162.96	163.33	163.70	164.07	164.44	164.81	165.18	165.55	165.92	166.30
45	166.67	167 04	167.41	167.78	168.15	168.52	168.89	169.26	169.63	170.00
46	170.37	170.74	171.11	171.48	171.85	172.22	172.59	172.96	173.33	173.70
47	174.07	174.44	174.81	175.18	175.55	175.92	176.29	176.66	177.03	177.41
48	177.78	178.15	178.52	178.89	179.26	179.63	180.00	180.37	180.74	181.11
49	181.48	181.85	182.22	182.59	182.96	183.33	183.70	184.07	184.44	184.81
50	185.18	185.55	185.92	186.29	186.66	187.03	187.40	187.77	188.14	188.52
51	188.89	189.26	189.63	190.00	190.37	190.74	191.11	191.48	191.85	192.22
52	192.59	192.96	193.33	193.70	194.07	194.44	194.81	195.18	195.55	195.93
53	196.30	196.67	197.04	197.41	197.78	198.15	198.52	198.89	199.26	199.63
54	200.00	200.37	200.74	201.11	201.48	201.85	202.22	202.59	202.96	203.33
55	203.70	204.07	204.44	204.81	205.18	205.55	205.92	206.29	206.66	207.03
56	207.41	207.78	208.15	208.52	208.89	209.26	209.63	210.00	210.37	210.74
57	211.11	211.48	211.85	212.22	212.59	212.96	213.33	213.70	214.07	214.44
58	214.81	215.18	215.55	215.92	216.29	216.66	217.03	217.40	217.77	218.15
59	218.52	218.89	219.26	219.63	220.00	220.37	220.74	221.11	221.48	221.85

	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
60	222.22	222.59	222.96	223.33	223.70	224.07	224.44	224.81	225.18	225.55
61	225.92	226.29	226.66	227.03	227.40	227.77	228.14	228.51	228.88	229.26
62	229.63	230.00	230.37	230.74	231.11	231.48	231.85	232.22	232.59	232.96
63	233.33	233.70	234.07	234.44	234.81	235.18	235.55	235.92	236.29	236.67
64	237.04	237.41	237.78	238.15	238.52	238.89	239.26	239.63	240.00	240.37
65	240.74	241.11	241.48	241.85	242.22	242.59	242.96	243.33	243.70	244.07
66	244.44	244.81	245.18	245.55	245.92	246.30	246.67	247.04	247.41	247.78
67	248.15	248.52	248.89	249.26	249.63	250.00	250.37	250.74	251.11	251.48
68	251.85	252.22	252.59	252.96	253.33	253.70	254.07	254.44	254.81	255.18
69	255.56	255.93	256.30	256.67	257.04	257.41	257.78	258.15	258.52	258.89
70	259.26	259.63	260.00	260.37	260.74	261.11	261.48	261.85	262.22	262.59
71	262.96	263.33	263.70	264.07	264.44	264.81	265.18	265.55	265.92	266.30
72	266.67	267.04	267.41	267.78	268.15	268.52	268.89	269.26	269.63	270.00
73	270.37	270.74	271.11	271.48	271.85	272.22	272.59	272.96	273.33	273.70
74	274.07	274.44	274.81	275.18	275.55	275.92	276.29	276.66	277.04	277.41
75	277.78	278.15	278.52	278.89	279.26	279.63	280.00	280.37	280.74	281.11
76	281.48	281.85	282.22	282.59	282.96	283.33	283.70	284.07	284.44	284.81
77	285.18	285.56	285.93	286.30	286.67	287.04	287.41	287.78	288.15	288.52
78	288.89	289.26	289.63	290.00	290.37	290.74	291.11	291.48	291.85	292.22
79	292.59	292.96	293.33	293.70	294.07	294.44	294.81	295.18	295.55	295.93
80	296.30	296.67	297.04	297.41	297.78	298.15	298.52	298.89	299.26	299.63
81	300.00	300.37	300.74	301.11	301.48	301.85	302.22	302.59	302.96	303.33
82	303.70	304.07	304.44	304.81	305.18	305.55	305.92	306.29	306.66	307.03
83	307.41	307.78	308.15	308.52	308.89	309.26	309.63	310.00	310.37	310.74
84	311.11	311.48	311.85	312.22	312.59	312.96	313.33	313.70	314.07	314.44
85	314.81	315.19	315.56	315.93	316.30	316.67	317.04	317.41	317.78	318.15
86	318.52	318.89	319.26	319.63	320.00	320.37	320.74	321.11	321.48	321.85
87	322.22	322.59	322.96	323.33	323.70	324.07	324.44	324.81	325.18	325.55
88	325.92	326.30	326.67	327.04	327.41	327.78	328.15	328.52	328.89	329.26
89	329.63	330.00	330.37	330.74	331.11	331.48	331.85	332.22	332.59	332.96
90	333.33	333.70	334.07	334.44	334.81	335.18	335.55	335.92	336.29	336.67
91	337.04	337.41	337.78	338.15	338.52	338.89	339.25	339.62	339.99	340.37
92	340.74	341.11	341.48	341.85	342.22	342.59	342.96	343.33	343.70	344.07
93	344.44	344.81	345.18	345.56	345.93	346.30	346.67	347.03	347.40	347.78
94	348.15	348.52	348.89	349.26	349.63	350.00	350.37	350.74	351.11	351.48
95	351.85	352.22	352.59	352.96	353.33	353.70	354.07	354.44	354.81	355.18
96	355.55	355.93	356.30	356.67	357.04	357.41	357.78	358.15	358.52	358.89
97	359.26	359.63	360.00	360.37	360.74	361.11	361.48	361.85	362.22	362.59
98	362.96	363.33	363.70	364.07	364.44	364.81	365.18	365.55	365.93	366.30
99	366.67	367.04	367.41	367.78	368.15	368.52	368.89	369.26	369.63	370.00
100	370.37	370.74	371.11	371.48	371.85	372.22	372.59	372.96	373.33	373.70
101	374.07	374.44	374.81	375.18	375.55	375.92	376.29	376.67	377.04	377.41
102	377.78	378.15	378.52	378.89	379.26	379.63	380.00	380.37	380.74	381.11
103	381.48	381.85	382.22	382.59	382.96	383.33	383.70	384.07	384.44	384 81
104	385.18	385.55	385.92	386.29	386.67	387.04	387.41	387.78	388.15	388.52
105	388.89	389.26	389.63	390.00	390.37	390.74	391.11	391.48	391.85	392.22
106	392.59	392.96	393.33	393.70	394.07	394.44	394.81	395.18	395.55	395.92
107	396.30	396.67	397.04	397.41	397.78	398.15	398.52	398.89	399.26	399.63
108	400.00	400.37	400.74	401.11	401.48	401.85	402.22	402.59	402.96	403.33
109	403.70	404.07	404.44	404.81	405.18	405.55	405.92	406.29	406.67	407.04
110	407.41	407.78	408.15	408.52	408.89	409.26	409.63	410.00	410.37	410.74
111	411.11	411.48	411.85	412.22	412.59	412.96	413.33	413.70	414.07	414.44
112	414.81	415.18	415.55	415.92	416.29	416.67	417.04	417.41	417.78	418.15
113	418.52	418.89	419.26	419.63	420.00	420.37	420.74	421.11	421.48	421.85
114	422.22	422.59	422.96	423.33	423.70	424.07	424.44	424.81	425.18	425.56
115	425.93	426.30	426.67	427.04	427.41	427.78	428.15	428.52	428.89	429.26
116	429.63	430.00	430.37	430.74	431.11	431.48	431.85	432.22	432.59	432.96
117	433.33	433.70	434.07	434.44	434.81	435.18	435.55	435.92	436.29	436.67
118	437.04	437.41	437.78	438.15	438.52	438.89	439.26	439.63	440.00	440.37
119	440.74	441.11	441.48	441.85	442.22	442.59	442.96	443.33	443.70	444.07

	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
120	444.44	444.81	445.18	445.55	445.92	446.29	446.67	447 04	447.41	447.78
121	448.15	448.52	448.89	449.26	449.63	450.00	450.37	450.74	451.11	451.48
122	451.85	452.22	452.59	452.96	453.33	453.70	454.07	454.44	454.81	455.18
123	455.55	455.92	456.29	456.67	457.04	457.41	457.78	458.15	458.52	458.89
124	459.26	459.63	460.00	460.37	460.74	461.11	461.48	461.85	462.22	462.59
125	462.96	463.33	463.70	464.07	464.44	464.81	465.18	465.55	465.93	466.30
126	466.67	467.04	467.41	467.78	468.15	468.52	468.89	469.26	469.63	470.00
127	470.37	470.74	471.11	471.48	471.85	472.22	472.59	472.96	473.33	473.70
128	474.07	474.44	474.81	475.18	475.56	475.93	476.30	476.67	477.04	477.41
129	477.78	478.15	478.52	478.89	479.26	479.63	480.00	480.37	480.74	481.11
130	481.48	481.85	482.22	482.59	482.96	483.33	483.70	484.07	484.44	484.81
131	485.18	485.55	485.92	486.29	486.67	487.04	487.41	487.78	488.15	488.52
132	488.89	489.26	489.63	490.00	490.37	490.74	491.11	491.48	491.85	492.22
133	492.59	492.96	493.33	493.70	494.07	494.44	494.81	495.19	495.56	495.93
134	496.30	496.67	497.04	497.41	497.78	498.15	498.52	498.89	499.26	499.63
135	500.00	500.37	500.74	501.11	501.48	501.85	502.22	502.59	502.96	503.33
136	503.70	504.07	504.44	504.81	505.18	505.56	505.93	506.30	506.67	507.04
137	507.41	507.78	508.15	508.52	508.89	509.26	509.63	510.00	510.37	510.74
138	511.11	511.48	511.85	512.22	512.59	512.96	513.33	513.70	514.07	514.44
139	514.81	515.18	515.55	515.92	516.29	516.67	517.04	517.41	517.78	518.15
140	518.52	518.89	519.26	519.63	520.00	520.37	520.74	521.11	521.48	521.85
141	522.22	522.59	522.96	523.33	523.70	524.07	524.44	524.81	525.19	525.56
142	525.93	526.30	526.67	527.04	527.41	527.78	528.15	528.52	528.89	529.26
143	529.63	530.00	530.37	530.74	531.11	531.48	531.85	532.22	532.59	532.94
144	533.33	533.70	534.07	534.44	534.81	535.18	535.56	535.93	536.30	536.67
145	537.04	537.41	537.78	538.15	538.52	538.89	539.26	539.63	540.00	540.37
146	540.74	541.11	541.48	541.85	542.22	542.59	542.96	543.33	543.70	544.07
147	544.44	544.81	545.18	545.56	545.93	546.30	546.67	547.04	547.41	547.78
148	548.15	548.52	548.89	549.26	549.63	550.00	550.37	550.74	551.11	551.48
149	551.85	552.22	552.59	552.96	553.33	553.70	554.07	554.44	554.81	555.18
150	555.55	555.93	556.30	556.67	557.04	557.41	557.78	558.15	558.52	558.89
151	559.26	559.63	560.00	560.37	560.74	561.11	561.48	561.85	562.22	562.59
152	562.96	563.33	563.70	564.07	564.44	564.81	565.18	565.56	565.93	566.30
153	566.67	567.04	567.41	567.78	568.15	568.52	568.89	569.26	569.63	570.00
154	570.37	570.74	571.11	571.48	571.85	572.22	572.59	572.96	573.33	573.70
155	574.07	574.44	574.81	575.18	575.56	575.93	576.30	576.67	577.04	577.41
156	577.78	578.15	578.52	578.89	579.26	579.63	580.00	580.37	580.74	581.11
157	581.48	581.85	582.22	582.59	582.96	583.33	583.70	584.07	584.44	584.81
158	585.18	585.55	585.92	586.29	586.66	587.04	587.41	587.78	588.15	588.52
159	588.89	589.26	589.63	590.00	590.37	590.74	591.11	591.48	591.85	592 22
160	592.59	592.96	593.33	593.70	594.07	594.44	594.81	595.18	595.55	595.92
161	596.29	596.67	597.04	597.41	597.78	598.15	598.52	598.89	599.26	599.63
162	600.00	600.37	600.74	601.11	601.48	601.85	602.22	602.59	602.96	603.33
163	603.70	604.07	604.44	604.81	605.18	605.55	605.92	606.30	606.67	607.04
164	607.41	607.78	608.15	608.52	608.89	609.26	609.63	610.00	610.37	610.74
165	611.11	611.48	611.85	612.22	612.59	612.96	613.33	613.70	614.07	614.44
166	614.81	615.18	615.55	615.92	616.29	616.67	617.04	617.41	617.78	618.15
167	618.52	618.89	619.26	619.63	620.00	620.37	620.74	621.11	621.48	621.85
168	622.22	622.59	622.96	623.33	623.70	624.07	624.44	624.81	625.18	625.56
169	625.93	626.30	626.67	627.04	627.41	627.78	628.15	628.52	628.89	629.26
170	629.63	630.00	630.37	630.74	631.11	631.48	631.85	632.22	632.59	632.96
171	633.33	633.70	634.07	634.44	634.81	635.18	635.55	635.92	636.29	636.66
172	637.04	637.40	637.77	638.14	638.51	638.88	639.25	639.62	639.99	640.37
173	640.74	641.11	641.48	641.85	642.22	642.59	642.96	643.33	643.70	644.07
174	644.44	644.81	645.18	645.55	645.92	646.29	646.66	647.03	647.41	647.78
175	648.15	648.52	648.89	649 26	649.63	650.00	650.37	650.74	651.11	651.48
176	651.85	652.22	652.59	652.96	653.33	653.70	654.07	654.44	654.81	655.18
177	655.56	655.93	656.30	656.67	657.04	657.41	657.78	658.15	658.52	658.89
178	659.26	659.63	660.00	660.37	660.74	661.11	661.48	661.85	662.22	662.59
179	662.96	663.33	663.70	664.07	664.44	664.81	665.18	665.55	665.92	666.29

	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
180	666.67	667.04	667.41	667.78	668.15	668.52	668.89	669.26	669.63	670.00
181	670.37	670.74	671.11	671.48	671.85	672.22	672.59	672.96	673.33	673.70
182	674.07	674.44	674.81	675.18	675.55	675.93	676 30	676.67	677.04	677.41
183	677.78	678.15	678.52	678.89	679.26	679.63	680.00	680.37	680.74	681.11
184	681.48	681.85	682.22	682.59	682.96	683.33	684.70	684.07	684.44	684.81
185	685.18	685.56	685.93	686 30	686.67	687.01	687.41	687.78	688.15	688.52
186	688.89	689.26	689.63	690.00	690.37	690.74	691.11	691.48	691.85	692.22
187	692.59	692.96	693.33	693 70	694.07	694.44	694.81	695.18	695.55	695.92
188	696.30	696.67	697.04	697.41	697.78	698.15	698.52	698.89	699.26	699.63
189	700.00	700.37	700.74	701.11	701.48	701.85	702.22	702.59	702.96	703.33
190	703.70	704.07	704.44	704.81	705.18	705.55	705.92	706.29	706.66	707.03
191	707.40	707.77	708.14	708.51	708.89	709.26	709 63	710.00	710.37	710.74
192	711.11	711.48	711.85	712 22	712.59	712.96	713.33	713.70	714.07	714.44
193	714.81	715.18	715.55	715.92	716.29	716.67	717.04	717.41	717.78	718.15
194	718.52	718.89	719.26	719.63	720.00	720.37	720.74	721.11	721.48	721.85
195	722.22	722.59	722.96	723.33	723.70	724.07	724.44	724.81	725.18	725.55
196	725.92	726.29	726.66	727.03	727.40	727.77	728.14	728.51	728.88	729.25
197	729.63	730.00	730.37	730.74	731.11	731.48	731.85	732.22	732.59	732.96
198	733.33	733.70	734.07	734.44	734.81	735.18	735.55	735.93	736.30	736.67
199	737.04	737.41	737.78	738.15	738.52	738.89	739.26	739.63	740.00	740.37
200	740.74	741.11	741.48	741.85	742.22	742.59	742.96	743.33	743.70	744.07
201	744.44	744.81	745.18	745 55	745.93	746.30	746.67	747.04	747.41	747.78
202	748.15	748.52	748.89	749.26	749.63	750.00	750 37	750.74	751.11	751.48
203	751.85	752.22	752.59	752.96	753.33	753.70	754.07	754.44	754.81	755.18
204	755.55	755.93	756.30	756.67	757.04	757.41	757.78	758.15	758.52	758.89
205	759.26	759.63	760.00	760.37	760.74	761.11	761.48	761.85	762.22	762.59
206	762.96	763.33	763.70	764.07	764.44	764.81	765.18	765.55	765.93	766.30
207	766.66	767.01	767.41	767.78	768.15	768.52	768 89	769.26	769.63	770.00
208	770.37	770.74	771.11	771.48	771.85	772.22	772.59	772.96	773.33	773.70
209	774.07	774.44	774.81	775.18	775.55	775.93	776.30	776.66	777.04	777.41
210	777.78	778.15	778.52	778.89	779.26	779.63	780.00	780.37	780.74	781.11
211	781.48	781.85	782.22	782 59	782.96	783.33	783.70	784.07	784.44	784.81
212	785.18	785.55	785.93	786 30	786.66	787.04	787.41	787.78	788.15	788.52
213	788.89	789.26	789.63	790.00	790.37	790.74	791 11	791.48	791.85	792.22
214	792.59	792.96	793.33	793.70	794.07	794.44	794.81	795.18	795.55	795.93
215	796.30	796.66	797.04	797.41	797.78	798.15	798.52	798.89	799.26	799.63
216	800.00	800.37	800.74	801 11	801.48	801.85	802 22	802.59	802.96	803.33
217	803.70	804.07	804.44	804 81	805.18	805.55	805.93	806.30	806.66	807.04
218	807.41	807.78	808.15	808.52	808.89	809.26	809 63	810.00	810.37	810.74
219	811.11	811.48	811.85	812.22	812.59	812.96	813.33	813.70	814.07	814.44
220	814.81	815.18	815.55	815.93	816.30	816.66	817.04	817.41	817.78	818.15
221	818.52	818.89	819.26	819.63	820.00	820.37	820.74	821.11	821.48	821.85
222	822.22	822.59	822.96	823.33	823.70	824.07	824.44	824.81	825.18	825.55
223	825.93	826.30	826.66	827.04	827.41	827.78	828.15	828.52	828.89	829.26
224	829.63	830.00	830.37	830.74	831.11	831.48	831.85	832.22	832.59	832.96
225	833.33	833.70	834.07	834.44	834.81	835.18	835 55	835.93	836.30	836.66
226	837.04	837.41	837.78	838 15	838.52	838.89	839 26	839.63	840.00	840.37
227	840.74	841.11	841.48	841.85	842.22	842.59	842.96	843.33	843.70	844.07
228	844.44	844.81	845.18	845.55	845.93	846.30	846 66	847.04	847.41	847.78
229	848.15	848.52	848.89	849.26	849.63	850.00	850.37	850.74	851.11	851.48
230	851.85	852.22	852.59	852 96	853.33	853.70	854.07	854.44	854.81	855.18
231	855.55	855.93	856.30	856 66	857 04	857.41	857 78	858.15	858.52	858.89
232	859.26	859.63	860.00	860 37	860.74	861.11	861.48	861.85	862.22	862.59
233	862.96	863.33	863.70	864 07	864.44	864.81	865.18	865.55	865.93	866.30
234	866.66	867.04	867.41	867.78	868.15	868.52	868.89	869.26	869.63	870.00
235	870.37	870.74	871.11	871.48	871.85	872.22	872.59	872.96	873.33	873.70
236	874.07	874.44	874.81	875.18	875.55	875.93	876.30	876.66	877.04	877.41
237	877.78	878.15	878.52	878.89	879.26	879.63	880.00	880.37	880.74	881.11
238	881.48	881.85	882.22	882.59	882.96	883.33	883 70	884.07	884.44	884.81
239	885.18	885.55	885.93	886.30	886.66	887.04	887.41	887.78	888.15	888.52

	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
240	888.88	889.26	889.63	890.00	890.37	890.74	891.11	891.48	891.85	892.22
241	892.59	892.96	893.33	893.70	894.07	894.44	894.81	895.18	895.55	895.93
242	896.30	896.66	897.04	897.41	897.78	898.15	898.52	898.88	899.26	899.63
243	900.00	900.37	900.74	901.11	901.48	901.85	902.22	902.59	902.96	903.33
244	903.70	904.07	904.44	904.81	905.18	905.55	905.93	906.30	906.66	907.04
245	907.41	907.78	908.15	908.52	908.88	909.26	909.63	910.00	910.37	910.74
246	911.11	911.48	911.85	912.22	912.59	912.96	913.33	913.70	914.07	914.44
247	914.81	915.18	915.55	915.93	916.30	916.66	917.04	917.41	917.78	918.15
248	918.52	918.88	919.26	919.63	920.00	920.37	920.74	921.11	921.48	921.85
249	922.22	922.59	922.96	923.33	923.70	924.07	924.44	924.81	925.18	925.55
250	925.92	926.30	926.66	927.04	927.41	927.78	928.15	928.52	928.88	929.26
251	929.63	930.00	930.37	930.74	931.11	931.48	931.85	932.22	932.59	932.96
252	933.33	933.70	934.07	934.44	934.81	935.18	935.55	935.92	936.30	936.66
253	937.04	937.41	937.78	938.15	938.52	938.88	939.26	939.63	940.00	940.37
254	940.74	941.11	941.48	941.85	942.22	942.59	942.96	943.33	943.70	944.07
255	944.44	944.81	945.18	945.55	945.92	946.30	946.66	947.04	947.41	947.78
256	948.15	948.52	948.88	949.26	949.63	950.00	950.37	950.74	951.11	951.48
257	951.85	952.22	952.59	952.96	953.33	953.70	954.07	954.44	954.81	955.18
258	955.55	955.92	956.30	956.66	957.04	957.41	957.78	958.15	958.52	958.88
259	959.26	959.63	960.00	960.37	960.74	961.11	961.48	961.85	962.22	962.59
260	962.96	963.33	963.70	964.07	964.44	964.81	965.18	965.55	965.92	966.30
261	966.66	967.04	967.41	967.78	968.15	968.52	968.88	969.26	969.63	970.00
262	970.37	970.74	971.11	971.48	971.85	972.22	972.59	972.96	973.33	973.70
263	974.07	974.44	974.81	975.18	975.55	975.92	976.30	976.66	977.04	977.41
264	977.78	978.15	978.52	978.88	979.26	979.63	980.00	980.37	980.74	981.11
265	981.48	981.85	982.22	982.59	982.96	983.33	983.70	984.07	984.44	984.81
266	985.18	985.55	985.92	986.30	986.66	987.04	987.41	987.78	988.15	988.52
267	988.88	989.26	989.63	990.00	990.37	990.74	991.11	991.48	991.85	992.22
268	992.59	992.96	993.33	993.70	994.07	994.44	994.81	995.18	995.55	995.92
269	996.30	996.66	997.04	997.41	997.78	998.15	998.52	998.88	999.26	999.63
270	1000.00	1000.37	1000.74	1001.11	1001.48	1001.85	1002.22	1002.59	1002.96	1003.33
271	1003.70	1004.07	1004.44	1004.81	1005.18	1005.55	1005.92	1006.30	1006.66	1007.04
272	1007.41	1007.78	1008.15	1008.52	1008.88	1009.26	1009.63	1010.00	1010.37	1010.74
273	1011.11	1011.48	1011.85	1012.22	1012.59	1012.96	1013.33	1013.70	1014.07	1014.44
274	1014.81	1015.18	1015.55	1015.92	1016.30	1016.66	1017.04	1017.41	1017.78	1018.15
275	1018.52	1018.88	1019.26	1019.63	1020.00	1020.37	1020.74	1021.11	1021.48	1021.85
276	1022.22	1022.59	1022.96	1023.33	1023.70	1024.07	1024.44	1024.81	1025.18	1025.55
277	1025.92	1026.30	1026.66	1027.04	1027.41	1027.78	1028.15	1028.52	1028.88	1029.26
278	1029.63	1030.00	1030.37	1030.74	1031.11	1031.48	1031.85	1032.22	1032.59	1032.96
279	1033.33	1033.70	1034.07	1034.44	1034.81	1035.18	1035.55	1035.92	1036.30	1036.66
280	1037.04	1037.41	1037.78	1038.15	1038.52	1038.88	1039.26	1039.63	1040.00	1040.37
281	1040.74	1041.11	1041.48	1041.85	1042.22	1042.59	1042.96	1043.33	1043.70	1044.07
282	1044.44	1044.81	1045.18	1045.55	1045.92	1046.30	1046.66	1047.04	1047.41	1047.78
283	1048.15	1048.52	1048.88	1049.26	1049.63	1050.00	1050.37	1050.74	1051.11	1051.48
284	1051.85	1052.22	1052.59	1052.96	1053.33	1053.70	1054.07	1054.44	1054.81	1055.18
285	1055.55	1055.92	1056.30	1056.66	1057.04	1057.41	1057.78	1058.15	1058.52	1058.88
286	1059.26	1059.63	1060.00	1060.37	1060.74	1061.11	1061.48	1061.85	1062.22	1062.59
287	1062.96	1063.33	1063.70	1064.07	1064.44	1064.81	1065.18	1065.55	1065.92	1066.30
288	1066.66	1067.04	1067.41	1067.78	1068.15	1068.52	1068.88	1069.26	1069.63	1070.00
289	1070.37	1070.74	1071.11	1071.48	1071.85	1072.22	1072.59	1072.96	1073.33	1073.70
290	1074.07	1074.44	1074.81	1075.18	1075.55	1075.92	1076.30	1076.66	1077.04	1077.41
291	1077.78	1078.15	1078.52	1078.88	1079.26	1079.63	1080.00	1080.37	1080.74	1081.11
292	1081.48	1081.85	1082.22	1082.59	1082.96	1083.33	1083.70	1084.07	1084.44	1084.81
293	1085.18	1085.55	1085.92	1086.30	1086.66	1087.04	1087.41	1087.78	1088.15	1088.52
294	1088.88	1089.26	1089.63	1090.00	1090.37	1090.74	1091.11	1091.48	1091.85	1092.22
295	1092.59	1092.96	1093.33	1093.70	1094.07	1094.44	1094.81	1095.18	1095.55	1095.92
296	1096.30	1096.66	1097.04	1097.41	1097.78	1098.15	1098.52	1098.88	1099.26	1099.63
297	1100.00	1100.37	1100.74	1101.11	1101.48	1101.85	1102.22	1102.59	1102.96	1103.33
298	1103.70	1104.07	1104.44	1104.81	1105.18	1105.55	1105.92	1106.30	1106.66	1107.04
299	1107.41	1107.78	1108.15	1108.52	1108.88	1109.26	1109.63	1110.00	1110.37	1110.74

EXCAVATION AND EMBANKMENT TABLES.

	0.00	0.10	0.20	0.30	0.40	0.50	0.60	0.70	0.80	0.90
300	1111.11	1111.48	1111.85	1112.22	1112.59	1112.96	1113.33	1113.70	1114.07	1114.44
301	1114.82	1115.19	1115.56	1115.93	1116.30	1116.67	1117.04	1117.41	1117.78	1118.15
302	1118.52	1118.89	1119.26	1119.63	1120.00	1120.37	1120.74	1121.11	1121.48	1121.85
303	1122.22	1122.59	1122.96	1123.33	1123.70	1124.07	1124.44	1124.82	1125.19	1125.56
304	1125.93	1126.30	1126.67	1127.04	1127.41	1127.78	1128.15	1128.52	1128.89	1129.26
305	1129.63	1130.00	1130.37	1130.74	1131.11	1131.48	1131.85	1132.22	1132.59	1132.96
306	1133.33	1133.70	1134.07	1134.44	1134.82	1135.19	1135.56	1135.93	1136.30	1137.67
307	1137.04	1137.41	1137.78	1138.15	1138.52	1138.89	1139.26	1139.63	1140.00	1140.37
308	1140.74	1141.11	1141.48	1141.85	1142.22	1142.59	1142.96	1143.33	1143.70	1144.07
309	1144.44	1144.82	1145.19	1145.56	1145.93	1146.30	1146.67	1147.04	1147.41	1147.78
310	1148.15	1148.52	1148.89	1149.26	1149.63	1150.00	1150.37	1150.74	1151.11	1151.48
311	1151.85	1152.22	1152.59	1152.96	1153.33	1153.70	1154.07	1154.44	1154.82	1155.19
312	1155.56	1155 93	1156.30	1156.67	1157.04	1157.41	1157.78	1158.15	1158 52	1158.89
313	1159.26	1159.63	1160.00	1160.37	1160.74	1161.11	1161.48	1161.85	1162.22	1162.59
314	1162.96	1163.33	1163.70	1164.07	1164.44	1164.82	1165.19	1165.56	1165.93	1166.30
315	1166.67	1167.04	1167.41	1167.78	1168.15	1168.52	1168.89	1169.26	1169.63	1170.00
316	1170.37	1170.74	1171.11	1171.48	1171.85	1172.22	1172.59	1172.96	1173.33	1173.70
317	1174.07	1174.44	1174.82	1175.19	1175.56	1175.93	1176.30	1176.67	1177.04	1177.41
318	1177.78	1178.15	1178.52	1178.89	1179.26	1179.63	1180.00	1180.37	1180.74	1181.11
319	1181.48	1181.85	1182.22	1182.59	1182.96	1183.33	1183.70	1184.07	1184.44	1184.82
320	1185.19	1185.56	1185.93	1186.30	1186.67	1187.04	1187.41	1187.78	1188.15	1188.52
321	1188.89	1189.26	1189.63	1190.00	1190.37	1190.74	1191.11	1191.48	1191.85	1192.22
322	1192.59	1192.96	1193.33	1193.70	1194.07	1194.44	1194.82	1195.19	1195.56	1195.93
323	1196.30	1196.67	1197.04	1197.41	1197.78	1198.15	1198.52	1198.89	1199.26	1199.63
324	1200.00	1200.37	1200.74	1201.11	1201.48	1201.85	1202.22	1202.59	1202.96	1203.33
325	1203.70	1204.07	1204.44	1204.82	1205.19	1205.56	1205.93	1206.30	1206.67	1207.04
326	1207.41	1207.78	1208.15	1208.52	1208.89	1209.26	1209.63	1210.00	1210.37	1210.74
327	1211.11	1211.48	1211.85	1212.22	1212.59	1212.96	1213.33	1213.70	1214.07	1214.44
328	1214.82	1215.19	1215.56	1215.93	1216.30	1216.67	1217.04	1217.41	1217.78	1218.15
329	1218.52	1218.89	1219.26	1219.63	1220.00	1220.37	1220.74	1221.11	1221.48	1221.86
330	1222.22	1222.59	1222.96	1223.33	1223.70	1224.07	1224.44	1224.81	1225.18	1225.55
331	1225.93	1226.30	1226.67	1227.04	1227.41	1227.78	1228.15	1228.52	1228.89	1229.26
332	1229.63	1230.00	1230.37	1230.74	1231.11	1231.48	1231.85	1232.22	1232.59	1232.96
333	1233.33	1233.70	1234.07	1234.44	1234.82	1235.19	1235.56	1235.93	1236.30	1236.67
334	1237.04	1237.41	1237.78	1238.15	1238.52	1238.89	1239.26	1239.63	1240.00	1240.37
335	1240.74	1241.11	1241.48	1241.85	1242.22	1242.59	1242.96	1243.33	1243.70	1244.07
336	1244.44	1244.82	1245.19	1245.56	1245.93	1246.30	1246.67	1247.04	1247.41	1247.78
337	1248.15	1248.52	1248.89	1249.26	1249.63	1250.00	1250.37	1250.74	1251.11	1251.48
338	1251.85	1252.22	1252.59	1252.96	1253.33	1253.70	1254.07	1254.44	1254.82	1255.19
339	1255.56	1255.93	1256.30	1256.67	1257.04	1257.41	1257.73	1258.15	1258.52	1258.89
340	1259.26	1259.63	1260.00	1260.37	1260.74	1261.11	1261.48	1261.85	1262 22	1262.59
341	1262.96	1263.33	1263.70	1264.07	1264.44	1264.82	1265.19	1265.56	1265.93	1266.30
342	1266.67	1267.04	1267.41	1267.78	1268.15	1268.52	1268.89	1269.26	1269.63	1270.00
343	1270.37	1270.74	1271.11	1271.48	1271.85	1272.22	1272.59	1272.96	1273.33	1273.70
344	1274.07	1274.44	1274.82	1275.19	1275.56	1275.93	1276.30	1276.67	1277.04	1277.41
345	1277.78	1278.15	1278.52	1278.89	1279.26	1279.63	1280.00	1280.37	1280.74	1281.11
346	1281.48	1281.85	1282.22	1282.59	1282.96	1283.33	1283.70	1284.07	1284.44	1284.82
347	1285.19	1285.56	1285.93	1286.30	1286.67	1287.04	1287.41	1287.78	1288.15	1288.52
348	1288.89	1289.26	1289.63	1290.00	1290.37	1290.74	1291.11	1291.48	1291.85	1292.22
349	1292.59	1292.96	1293.33	1293.70	1294.07	1294.44	1294.82	1295.19	1295.56	1295.93
350	1296.30	1296.67	1297.04	1297.41	1297.78	1298.15	1298.52	1298 89	1299.26	1299.63
351	1300.00	1300.37	1300.74	1301.11	1301.48	1301.85	1302.22	1302.59	1302.96	1303 33
352	1303.70	1304.07	1304.44	1304.82	1305.19	1305.56	1305.93	1306.30	1306 67	1307.04
353	1307.41	1307.78	1308.15	1308.52	1308.89	1309.26	1309.63	1310.00	1310.37	1310.74
354	1311.11	1311.48	1311.85	1312.22	1312.59	1312.96	1313.33	1313.70	1314 07	1314 44
355	1314.82	1315.19	1315.56	1315.93	1316.30	1316.67	1317.04	1317.41	1317.78	1318.15
356	1318.52	1318.89	1319.26	1319.63	1320.00	1320.37	1320.74	1321.11	1321.48	1321.86
357	1322.22	1322.59	1322.96	1323.33	1323.70	1324.07	1324.44	1324.81	1325.18	1325.55
358	1325.93	1326.30	1326.67	1327.04	1327.41	1327.78	1328.15	1328.52	1328.89	1329.26
359	1329.63	1330.00	1330.37	1330.74	1331.11	1331.48	1331.85	1332.22	1332.59	1332.96

INSTRUCTIONS TO DIVISION AND ASSISTANT ENGINEERS RELATIVE TO FIELD NOTES ON SURVEYS FOR THE SOUTH PENNA. R. R. CO.

First—Enter the names of the Division Engineer, Senior Assistant Engineer in charge of the party, Assistant Engineer at Transit Instrument, Assistant Engineer at Leveling Instrument, Rodmen, Chainmen, Flagman, Axemen, composing the party. Rodmen must make the same notes, also enter the date and place where the work is..

Second—State in the column of remarks on the first or second page of the book at the beginning of the notes of any survey or levels, the letter of the line and where it was begun and where it is to be run to.

Third—The Stakes of all lines must be numbered on the rear face, next to the transit, and must be lettered on the forward face, with the letter of the line. A'l lines must be lettered.

Fourth—State what Datum the Levels start from or refer to, and if started from a Bench state what Bench and from what authority or book the Elevation was obtained.

Fifth—Enter all notes of Transit or Level fully and distinctly in pencil in the field—if any details or calculations are omitted from haste or sudden storms coming up—make them complete before the day is over, and when required by the Senior Assistant or Division Engineer, they must be recorded in a Record Book the same evening.

Sixth—All field notes must be compared during the day taken, and all Levelers' calculations on turning points must be made by Assistant and Rodman, and compared on the spot and found correct before going forward with the work.

Seventh—Benches must be made at least once in every mile, and oftener if opportunity offers. Levels must be tested on any existing Benches found along the line, and tests made of the accuracy of the old and new works. Benches must not be cut on shade or fruit trees and no unnecessary damage done in clearing the line of sight; offsets must be made to save valuable trees

Eighth—In passing through inclosed land the Senior Assistant will see that the fences taken down by the party are put up after they pass forward.

Ninth—The Assistant at the Transit must record the names of land owners, the points where boundaries are crossed, and their courses when obtainable.

Tenth—Chiefs of Party must arrange to get the party out and at their work as early as possible in the morning, and keep them employed until the proper hour in the evening. All preparations for the field work must be made by the Senior Assistant and Assistants the previous evening, so that no delays may occur in the morning. Dinner will be procured by the Senior Assistant to be eaten in the field when the party is more than one mile from boarding places.

Boarding expenses paid by any members of the party will be reported to the Senior Assistant and will be repaid by the company at the end of the month.

Eleventh—Senior Assistants will see that the instruments, rods and chains are kept in good order and adjustment by the Assistants; any damage to instruments or rods from want of proper care must be defrayed by the Assistant having the same in charge.

Twelfth—Daily notes of the work done and the date must be entered in this field book every evening.

Thirteenth—Assistant Engineers in charge of the Transit must plot their lines, and Assistants in charge of the Level must, with the aid of their Rodman, make a profile every evening, of the line leveled over each day.

Fourteenth—Division and Senior Assistant Engineers will make reports of instruments and stationary on hand at the close of each month, and send them in promptly to the General Office.

Fifteenth—Division Engineers must report any neglect of these instructions to the Chief Assistant Engineer.

OLIVER W. BARNES, Chief Engineer.

Engineering Field Work.*

CHAPTER VI.

THE SURVEYS.

The three classes of surveys, viz: Preliminary, Location, and Construction, form as good divisions as can be suggested for this subject, and we will consider them in order.

PRELIMINARY.

The object of a Preliminary survey is to ascertain whether it be feasible to build a line of railway between two points upon the surface of the earth, and this information is obtained for certain parties who wish to make money in some way or other by constructing or having such line of railroad constructed. For this purpose the parties employ a more or less competent engineer to make these surveys, giving him authority to employ one or more field parties according to the magnitude of the work, and the money they may think they can spend upon it. If only one party is employed it is sometimes under the direction of the chief engineer himself, but more commonly under an assistant employed by him.

ORGANIZATION OF FIELD PARTY.

The organization of this field party is usually, as follows:

1. The Assistant in charge of the party.
2. The Transitman, whose work is running the line and keeping all notes thereof.
3. The Leveler, whose work is taking levels, drawing the profiles and making the estimates therefrom.
4. The Level rodman, assistant to the Leveler.
5. The head chainman, who should also carry the transit rod and get therewith the lines given by the transitman.
6. The hind chainman, who should also number the stakes and keep a record of all distances measured.
7. From one to five axemen according to the amount of chopping required by the work.

* Written by the late CHAS. A. SMITH, C. E., Professor of Civil and Mechanical Engineering at Washington University, St. Louis, and published in ENGINEERING NEWS, Vol. III. 1876.

These may be considered about all the men needed for the professional part of the work, and if the country is inhabited will be all that will be employed; if there are only a few inhabitants a team and driver may be advantageous, but if uninhabited and it becomes necessary to take a camp outfit, at least two more men are indispensable—a teamster and a cook, the latter being a very important member of the party.

THE ENGINEER-IN-CHARGE.

The duties of the engineer-in-charge of the party are too many for enumeration here, but he has to see that the greatest amount of work possible is done for the money expended; his business is to get information for the chief engineer and to keep his party running without delay. A word of brotherly advice to him may not come amiss and is meant kindly if it is not necessary.

CARE OF MEN.

In selecting your party for a start use judgement and your knowledge of human nature; don't get two men who have a feud with each other in the same party if it can be helped. Study your men all the time and be frank and free with them; do not talk much with them in working hours, but watch all hands very closely, for the first few days especially. Remember that your men are men, and treat them well: show them that you know how the work should be done, but don't "nag" them all the time; if you have a horse, don't keep them at work till dark and then ride off and leave them to walk three or four miles to supper, but either quit work in decent season or lend your horse to some fellow who is fagged, and walk in with your men; don't hang round in the morning and let your men wait for you, but pick up an axe or rod and start first for the work; get into good training for walking, and if you start for supper last passall the men on the road; don't shirk work yourself, and don't let any body else shirk; never ask a man to do any work you would not be willing to do yourself,—we remember "stripping to the buff" and wading a stream four feet deep when the cakes of ice were coming down, because we thought the men hung back and did not want to go into the water; don't worry the transitman's wits out of his head by asking him questions; find out what he is doing and recording, but don't crowd him too hard or bluster about him; don't swear habitually before the men if you

can help it; you may want to swear at them some times, and if not used to it they will be more apt to obey; don't scold a man when you are angry yourself, if you can help it, but wait and talk to him after supper, when you have cooled down.

THE COOK.

In selecting a camp outfit be especially careful to get a good cook, and we advise a good cooking stove of cast iron with enough pipe to draw well,—we remember a sheet iron stove which had to be taken down every morning and the soot kicked out of it before a fire could be made to "draw," and we also remember the satisfaction with which the boys kicked the miserable thing to pieces after it had been "returned" at headquarters. We are more particular in this matter, not only because we like to be well fed, but because men must be well fed in order to work well—and you must remember that poor food will make bad temper and bad work, and that the interests of your employers demand that you keep your men contented with their job. So much for the *care* of the men.

ON THE LINE.

Don't let your leveler get too far behind the transit work, and see that he checks his levels and establishes benches at proper intervals. After the work is well started you will be obliged to go ahead and make yourself familiar with the features of the country and select the points where your line must be run. A preliminary line is usually run without curves, and the work of the transitman is much easier than in location surveys, and the line work is much more easily carried on than when locating; and this brings us to the work of the transitman. But before leaving this part of the subject let me remind you, that as your work progresses, you will have to come in contact with the property holders and residents of the country, and you should always bear in mind that you represent large interests and can give them by your manner a favorable or unfavorable impression as you choose.

THE TRANSITMAN.

The transitman has the hardest work of the party to perform; he has to stand with one eye at his instrument as long as the men can set stakes, and then when he is called up, the whole chain and axe force have to be idle till he arrives at the place where they are

and has set up and lined his instrument; he is supposed to direct the work in the absence of his superiors, to know the topography of the country ahead and run his line to suit the ground—to keep all the men at work and not let them loaf around—to keep all notes, and if possible sketch all the topography; to act as chie assistant in every way, to be book-keeper and cashier of the party; if in camp, to purchase supplies and see that things go right generally. The skill of the transitman in the field consists in his realization of the peculiar features of the ground and his judgment in running to them, and to his being able to work under mental pressure. The mere instrumental work in a preliminary survey is easy to do, as it consists only in running bearings, noting angles and giving the line to the men at the chain. A few words to the transitman: Carry your instrument yourself; don't let any of the men take it at night unless you are just ready to drop with fatigue. Your men may very probably offer to carry your instrument, as a common courtesy, or even to make friends with you, but don't accept such favors; among working men, from which class your chainmen and axemen will most probably come, there is but one standard of comparison, and that is strength, and although one of them may be perfectly willing to shoulder your fifteen pound transit for three or four miles, you will not gain his respect by letting him do it for you. If you have not strength, make up for it in endurance and quiet pluck, and if you want to grumble, don't do it before the men. You and the engineer-in-charge must be in perfect accord, at least in appearance, if you want to further the interests of your employers and your own also. In setting up a transit on sideling ground it is generally better to put one leg of the tripod up hill and two down, but you must exercise a little common sense in the matter; try to keep the lower "parallel plate" as level as possible, as by so doing time in "leveling up" will be saved; try to make yourself master of your instrument as there is a great range in the value of transitmen, and try to "set up" each time a little quicker than before, and also a little better. The acme of setting a transit may be considered reached when one shove on each leg of the tripod brings the "plumb-bob" exactly over the point in the stake, while the instrument is found level "both ways." Try and see how many times you can do this every day, but don't waste time studying how to do it at each "set." It is rather better to keep the plates clamped together at zero, and do all lining of the instrument with the lower clamp and tangent;

take bearings on both fore and back sights as you may detect errors in reading angles by so doing, and be careful to record which way angles are turned. It is most convenient to run your transit ahead always and read the same end of the needle if the instrument is in as good adjustment as it should be. The stability of the adjustment differs very widely in different instruments. We have worked with an instrument for three months which never had to be touched, and also with another from the same maker which would not reverse truly for the day, although adjusted every morning; it becomes necessary, therefore, to learn the peculiarities of your instrument, and know, not guess at, its condition at all times. The reversal should be tested each morning before going to work until you are sure of the instrument. Learn which way to get the slack of the tangent screws, and to do good work with a poor transit.

THE LEVELER.

The leveler on a preliminary survey may have to work at his best to keep up with the transit party, and as the leveler and rodman have to work completely in unison, we will give them our advice together after their field work. Of course, in the office, or in camp they are two very different people, the leveler being one of the commissioned officers of the party, if we may use a military term, while the rodman is about the grade of a sergeant only. Still there should be very little difference of feeling between them. The leveler keeps all field notes and the rodman should also carry a book and keep the turning point sights and work out all heights of the instrument and elevations of turning points and benches in t e field. Readings for turning points and benches may be taken to the thousandths, but for station heights the nearest tenth only should be read.

LEVELING.

Make all the vertical height you can in going up or down hill as you may save a setting thereby. Study the ground as to what is coming ahead and never select turning points or set up the instrument without having fully considered what is to be done next.

Be sure of the adjustments of the instrument and that the rod is held "plumb" (if the cross hairs are right, the man at the instru-

ment can see by the vertical hair if the rod is "plumb" one way, and by gently swinging the rod in the plane of the instrument after setting the target if the target rises above the hair, the rod was not held "plumb;" if the target on swinging the rod, falls below and just comes up to the hair, the rod has been held vertically). Make your signals with some system, and move the rod according to the signal in amount of motion as well as direction, speak your numbers distinctly and don't mistake the word seven for eleven, or the reverse.

Leveling can be hurried in open country by employing two rodmen and rods, and running them alternately, the employment of a fourth man to keep notes in such case being a great help, although such great haste is not often required or desirable.

Put in benches at least once in 1,500 feet in open country, and every 1,000 feet in rough country, as it may save you a good deal of work; select good points for benches and turning points, and always be sure that the instrument may be moved before you move it, and that you can find at least half of the turning points in the day's work.

In running "check levels" check up the benches every mile, and if the agreement is within one-tenth, call bench right and go on. Try to keep the check levels within two miles of each other, as it may save a good deal of annoyance.

The work of the rest of the party is much the same for location and preliminary surveys, and will be described further on. The engineer in charge of the party and the transitman are the ones whose work is increased the most, and their duties will be described again for location survey.

THE HEAD CHAINMAN.

The head chainman holds an important position and must be a man with sound judgment, and must understand his work. He should hold the transit rod with one hand, and the chain with the other, showing discretion as to holding the chain level and taking short lengths on hilly ground; he should understand the signals of the transitman and obey them intelligently; should have a good eye for line and use it every time he holds his rod up, so as to be as nearly right as may be before the transitman begins to signal to him; and he should always look at the transitman when lining, instead of gazing around at other things. His work is perhaps best conducted in the following order: When the chain is pulled out

he turns around, and holding the rod with one hand, tries to place it as nearly correct as he can by lining over the last stake to the instrument, while with the other hand he is trying to "straighten out the chain;" he then moves the rod in obedience to the motions of the man at the instrument, and after getting the line, holds the chain up to the rod with both hands and gets the distance; then dropping the chain he stands up straight, plumbs the rod carefully and receives the line again; then pressing the rod into the ground he makes the hole with the point, and takes it off the ground: a stake is then driven and the measurement should be repeated to see if the distance is correct, after which the rod is held on the stake "for line," the chain is then dragged on and the operation repeated. Time may be lost by neglecting the order of operations given above, or by not looking to see where the line is, and leaving all the movements to be signalled from the instrument, or by jerking the chain while trying to straighten it, or by not watching the transitman closely, and thus missing his signals. If you are so far away that the motion cannot be seen, take your handkerchief or hat and make a signal (imitating the lining signals) and the transitman will understand that you wish him to take his handkerchief, (when snow is on the ground, his hat) to increase the visibility of his signal. Remember that the transitman can see you plainly, and can guess what you may wish him to do. When you wish him to line you hold up your rod and wave it to catch his eye, and when you are sure that the line can go no further without a change in the position of the instrument, you must call his attention by holding your rod in both hands horizontally above your head; then after carefully lining and centering, you can call him up by beckoning with both hands, holding the rod above your head or by any other previously arranged signal.

SELECTION OF TRANSIT POINTS.

By far the most important duty in point of difficulty, is the selection of the transit points, which must be so chosen that the greatest distance ahead may be seen from them; in general they should be on the upper edges of hills, where a view of the valley on both slopes can be obtained, and if possible, where a full view of the transit rod can be had, as it is only allowable in case of necessity to sight at but a small part of the rod, and therefore great care must be taken to hold "plumb" at all times, as you do not know just how much of the rod may be observed. You must exercise consid-

erable judgment in the matter, and never be astonished if your views and the transitman's differ on this point. And here let us say a word to all the men; remember that the transitman has to work all the time, and that he has to take all the blame from the engineer-in-charge for all mistakes, and that if he does scold you for things that are not your fault, just wait till the matter developes, but do not try to argue during working hours about the work; if you have been to blame, you deserve "jawing," and if you have not, it will not hurt you a bit in the eyes of anybody whose opinion is worth having. The same remarks will apply to the transitmen and levelers in their relations to their superior; let them remember that the engineer-in-charge has more things to think about in a day than they have in a week, and if they don't believe it, wait until they have the same position and can see for themselves.

THE REAR CHAINMAN.

The work of the rear chainman is to hold the chain while it is being pulled along; we say hold it, for if you let the end go you may have to call the front chainman back for 10 or 20 feet after he has passed his proper distance, and he won't like that. Don't hang on the chain and be dragged by it, but be ready to give it a shake and clear it if it catches on brush or rocks. The rear chainman is responsible for the numbering of the stakes, and for all distances with "plus" numbers; he must be careful to assist in straightening the chain, to be on hand promptly in measuring, and not get in the line nor walk on the line, and not to jerk the front chainman's arms off by suddenly stopping. The keeping of the numbers right is a more difficult task than it seems to be, and requires a good memory; in all cases of doubt, go back and find out at the last stake what is right and don't guess at it. Be careful that the chain is in good order—that the links are straight and that the rings are not pulled open. Do it up from the handle and keep the strap around it; learn to throw a chain over a stream; one end of an ordinary heavy chain can be thrown over a 50 feet stream. And by making two bundles with say 15 feet between them, and using two men to throw, one after the other (at say half a second interval), we have thrown the end of a heavy chain 75 feet. Be careful that the chain is not dragged against the transit legs, and do not hit them while trying to stand the straightening as inflicted by the head chainman; be prompt to assist in making short chains on hilly ground, and on curves, if there are any, and walk the outer side

of the line lest you get in the "line" of the instrument without knowing it.

THE AXEMEN.

The axemen are under the general direction of the head chainman who gives the line for cutting brush and timber with his rod. One axeman must be in charge of the stakes and must never let the chain work wait for him a second, but must keep up at all risk. Sometimes a large basket is useful in carrying stakes. The stakes should be numbered by the chainman, and if he marks a number of them in the basket, care must be taken to see that in "plus" stations the numbered stakes are not used, or the numbers may get "mixed."

LOCATION.

In location surveys the only difference in the work of the men is in the curve work, where the head chainman has to offset from the line of the last stake to find the transit "line" by an amount known as the chord "deflection," for which see "Henck's Field Book." We always gave the chainman a list of "chord deflections" for the even degrees, and let him guess at the amount of the ground, and found that it saved time. The centering of the stakes should be attended to a little more carefully than on preliminary work, and the measurements made with more care.

A back rodman will be necessary, and we can only caution him to stand up, with his rod in position all the time, or if near enough to see, whenever the transitman turns over his telescope, he must be on hand. Although the job is not very interesting it is important. We used to let the back rodman carry the coats, and if we took our dinner along, a basket with the "grub."

Each man in the party must be held strictly responsible for what tools or instruments are put into his hands, and a careful property account must be kept and reported from time to time.

WASTEFULNESS OF CARELESS LOCATION.

Location surveys differ from preliminary surveys in being more carefully carried out, as to the exact position of the line, and in the curve running, which is usually omitted on the preliminary work. The exact position of the line is a matter of great importance, for many dollars are thrown away by careless locations and in many cases the theory of wilful ignorance is the only excuse that can be

made for them. There are needed careful judgment, long experience, and a great deal of real hard work on the part of the engineer in charge of the locating party, to make successful locations.

THE TOPOGRAPHER.

The party is usually organized with the same force as in the preliminary survey, viz: An engineer-in-charge, transitman, leveler, level rodman, two chainmen and from one to five axemen. To these are often added a topographer, and sometimes a cross-section leveler and helper or rodman. The topographer takes sketch-notes of the contours and surrounding country, roads, buildings etc., which have to be shown in the plans, and if he carries a pocket "azimuth compass," or a pocket sextant, he will find it a great help to him, but for his work we especially recommend a small plane table, 18 inches square, with the paper on it in "block" fashion, the board fitted with a shoulder strap, and Jacob staff mountings, and a folding "alidade" or ruler, with sights. With this outfit a topographer can produce a line map which will make his chief engineer's heart glad, and which will go a long way towards convincing the directors that the party have done a lot of work. The use of the plane table for this purpose is not common, but such an arrangement costs very little, and nothing else will show as much of the country in a very short time. The field use of the instrument is very simple; the line already run being platted before taking the field, the "orientation" can be performed from stakes and it can be used anywhere.

The cross-section leveling is only performed in very rough country; a 10-foot pole with a short spirit level placed on it, and then held with one end on the ground and the other against a graduated rod on which the rise or fall in 10 feet is noted, is used; the information obtained in this way is very considerable; there is a good deal of work to get it but the men are not required to have a very high grade of mental organization and do not draw a very high pay.

ENGINEER IN CHARGE.

All of the increased care and skill required and already mentioned has to come from two men—the engineer-in-charge and the transitman—the former has all the responsibility of the added importance of the survey, and the constant study of the ever changing ground, and the greater or less difficulty of the work itself; and

the latter has all the curve work, with increased watchfulness and greater accuracy, to attend to; those two men have their work nearly doubled, while the work of the rest of the party is only increased by the additional care and attention which has to be enforced on all the party.

To the engineer-in-charge we shall say very little, and to a man in that position little can be said—if he does not know his business he certainly ought not to be in the place, and if he does know it, our advice is unnecessary, yet if he does not think it beneath him to read what we have to say to transitmen, he may here and there find a hint to help him in watching the work of that indispensable assistant. And here let us say that no money is ever saved by making the engineer-in-charge of the location run either transit or level, as he needs all of his faculties to be at all times sharpened to their utmost degree to attend to his own duties, and if the tedious instrumental work is put upon him he cannot keep everything going at once properly. And let us say also, that if the engineer-in-charge wishes to make every man do his very utmost, that he had better take the head of the chain himself when he can spare the time, especially on long tangents, which he has already determined. By so doing he will be near all the men of the transit party, and they will work when they are right under the eye of the "boss," and he will be sure that no time will be lost in picking out the transit stations, and that the stakes are kept well up; the transitman will always hurry up to him, and if he cannot keep them all "on the jump," he is not fit for his place. Of course, he has frequently to go ahead and pick out the ground, and go back to see how the profile will plat, and tell the transitman what must be done in his absence, and in this he must be his own judge of his time and of its disposition, but still, when he wishes to drive matters, he can do so best from the head of the chain, in the meantime letting the head chainman take the transit rod and keep up the centers; the mental work which he has to perform all the time will not suffer from the mere manual labor of being head chainman.

KEEPING TRANSIT NOTES.

The transitman has after all a hard place to fill, for there is no variety in his mental work; he has to keep a sharp watch on the men when his superior is absent, and has the constant computation of deflection angles to attend to on curves, at the same time

using all possible diligence as to figures. And here a hint as to the easiest way of keeping the curve notes and doing the transit work. The method originated we know not how, and may have have been used by large numbers of transitmen, although we have never happened to meet them.

The basis of all circular curve work with the transit is the well known theroem: the angle between a tangent chord, or between any two chords which meet at a point on the curve, is measured by half the intercepted arc. And as the point where the chords meet on the curve may be anywhere on that curve, it follows that the sum of any consecutive angles or series of angles is the same no matter where the instrument be placed on the curve for given arcs, and that if the deflection angles be all computed from the B. C., as far as may be desired, at any station on the curve the number can be used, as the differences will be the same for the same stations. To illustrate this, we must assume an example.

Let it be required to run a five degree curve from sta. 131 + 40, and let us first look at a page in a field book:

STATIONS.	DEFLECTIONS.	CURVE.	TRUE COURSE.	NEEDLE COURSE.
129			N 16½° W	N 16° W
130				
B. C. +40	0°0′	5°R.	N 16°15′ W	
2	1°30′			
3	4°0′			
4	6°30′			
5	9°0′			
+50	10°15′			
6	11°30′			
7	14°0′			
8	16°30′			
E. C. +25	17°7½	34°15′	N 18° 0′ E	N 17¾° E

We see the book is ruled with five columns and usually on the left hand page, the right hand page being reserved for "remarks." The column for Stations explains itself, the signs "plus" being used, decimal points for a hundred foot unit, and the ordinary "decimal" being reserved for feet and fractions of feet. The letters B. C. and E. C. are used for beginning and end of the curve, instead of the P. C. and P. T. used often for "point of curve" and "point of tangent," being more in accordance with the usage of ordinary geometry and has been our custom for several years.

The column of deflections contains the deflection angles computed from B. C. as far as convenient, say to station 135, and the stakes set and centered, for same reason 135 + 50 becomes necessary and has to be put in; then the transit is turned back to 0° and turned over on the back sight to be sure that nothing has slipped and carried up to 135+50, and set up. The instrument is then set at 0° and sighted at B. C. and then if turned to 10° 15′ it would be on the tangent at 135 + 50, and if turned to 11° 30′, it will be on the chord from 135 + 50 to 136, and by adding these 2° 30′ for each hundred feet the curve is run to 138 and the transit is moved to that place after taking a back sight as before, with the plates at 0°. After setting up at 138 if we could see B. C. we should set at 0° again, and turning to 16° 30′ we would be on the tangent; but B. C. is supposed invisible, and we shall therefore set the instrument at 10° 15′ and sight it back at 135 + 50 and the result is that the lower plate is in the same position as if B. C. had been visible, and we had as above suggested set 0° and sighted thereat; by turning to 16° 30′ we shall be on the tangent at 130 and if we find that 1° 20′ more will be needed to strike the desired direction from there, we will put 1° 15′ more in the curve or 37½′ deflection which corresponds to 25 feet; we run out the 25 feet and turn to10½′ and sight the stake in, and then turning to 10°15′, we turn over to the back sight; after satisfying ourselves that it is all right, we go to 138 + 25 and being sure the instrument reads 10°15, we sight again at 135 + 50 and turn to 17°7½′ and are at the tangent. By taking the differences and comparing distances it will easily be seen that the angles are all right.

Now in what does this method consist that is better than the practice of counting stations and multiplying by the deflection angle? Only this, that the counting and multiplication are both performed already. Each station is attached to the angle opposite to it in the note book, and once there it is good for all the work that you can do with it. The mental labor thus saved is a great help. It was once our fortune to have to "break in" two "green" transitmen in five weeks, and in all that time we computed every angle that was used at the instrument, mentally, and kept at the head of the chain most of the time; by asking the man at the instrument what reading he had and what station he was at and what his back rodman was at, we never let a mistake pass our notice. (*Note.*—We are not anxious to repeat this experience of our transit running from the head of the chain.)

For the transitman himself this system of notes is a great relief as he is free from the constantly recurring question "what is your next deflection?" with its importunate worrying when he has just set up on an odd "plus" and knows that his back rodman is also on an odd "plus," he simply asks himself, what are the readings for these two stations knowing that the difference between them has been computed carefully once as they come along, and it will be all right now.

COMPOUND CURVES.

On compound curves the same method can be followed all around, but the back rodman and the instrument must be on the same branch (the P. C. C., point of compounding of curve, is of course on both branches). The next column of the note book is headed "curves" and in it are recorded the degree and direction of the curves and the central angle, or angle of intersection; it is twice the last deflection angle always. In the next column is put up the computed curves from the first one, and the next one contains the needle readings; the use of these is a check to the transitman's work and sudden variations are not common. If "local attraction" exist, it can be found by reading the compass at each end of the tangent. We remember a local attraction which bothered us all one morning and which never seemed to be the same for two minutes running, and which quite frightened our "boss" but as we were within fifty feet of a north and south track, we talked "earth currents" at him (they were east and west) and as we were sure of our work we let it go unexplained; in the afternoon we discovered the innocent cause to be a small "Smith & Wesson" in our overcoat breast pocket, and we have never seen any such local attraction since.

LONG TANGENTS.

Long straight lines require a good deal of care, and the instrument should be reversed "both ways" on them, and if a long sight can be obtained backward so as to overlook two or three transit points, they should be tested by the direct instrument. If great care is needed, the instrument should be used "both ways" without reversing, and the slack of the clamp screws watched. Tangent screws are now so generally made double that the play of the motion screws can be prevented from interfering with the ac-

curacy of the work, but the clamps will wear loose a little and must be watched.

LAND LINES.

In Railway field work, after the location survey, follows legitimately the land survey or "land lines" as they are called in the east, and although most of this work is included in common surveying, yet there are some points of difference which it will be well to touch upon. In cities and towns where land is valuable, it is of course quite important to have the work done accurately; and although in the western country, where the land is very commonly given to the railroad company it is not so essential, still it is always desirable to know how to do good work, and a few words as to general surveying will scarcely be out of place.

In the first place be sure that your work is definitely connected with points which can be found again, and that the connection with the main line is right, and that it is simple; any complex measurement is to be avoided. In the next place, measure every distance pertinent to the work which can be directly measured. Calculate as little as possible. If the land to be taken is very irregular in form, a "traverse" is the best method of attack if all the sides can be measured; don't have any "omissions" to supply if you can help it; be careful to take all offsets at right angles; take the angles with a transit if one can be had, and do not use the compass in any way but as a check on the transit; for sighting right angles quickly, some of the forms of the "optical square" may be found very convenient; for ordinary work in cities most of the measurements for land will be at right angles or nearly so, and the work can be laid out on four lines forming a trapezium; do not trust to any building for a right angle or to any two walls of the same building to have parallel faces; brick laying is not by any means the most exact of trades, and although for a map the errors will not show, yet for other work to be connected to that in progress, it may lead to serious errors.

For railroad purposes the land is usually found in long narrow strips of varying width; and it is sufficient to find the length on the centre line, and directions of bounding lines which cross; it is however, desirable to have all "land lines" within four or five hundred feet of the track, and this requires measurements on the crossing lines. In getting the direction of a fence, when the instru-

ment is placed at one side, measure the distance from the instrument to the fence at right angles to it and have a similar "offset" made as far as possible from the instrument; of course the main line should have been run and the transit placed in the line before the direction can be obtained.

For street surveying the best method is that of a line in the middle, with offsets and measurements connecting, the offsets at the end as well as the line run. In very crowded streets we have sometimes run a line down each footwalk, connected them carefully at their ends, and then proceeded as described for a single line.

CAREFUL NOTES

In all work of this kind the most important thing is to take good notes; always put these down as if you expected to die before morning, and wanted to leave them in such good condition that in ten years time a stranger with no previous acquaintance, and with no one of the old party to help him, could take your book and proceed on the job without delay; if this can be done, your notes must be about right, but you never will have them too complete. We have never used any but the "sketch system" for taking notes, and we always made them in the field, and copied them over on the next page in ink, thus keeping the rough set with the original figures, and the finished set to explain them; the original figures have more weight as evidence, but the explanation given by a neat ink copy is a very great help in interpreting them. For city work take all angles with the transit more than once, that is to say, "repeat them," three or four times which is enough; the object of the "repeating" being to check the angle and not to subdivide the vernier reading.

PRESERVING THE LINES

After the completion of the land survey comes the actual field work preparatory to the construction, and here it is customary to reduce the number of men in the party and to begin to "cut down expenses" in the engineering department.

The first thing to be done is to "preserve" the line, that is, to connect all tangent points with stakes that are away from the line and far enough from it not to be disturbed by the operations of grading and earthwork; at the same time the slope stakes should be set and marked with the cut and fill—also the cut or fill should be marked on the centre stakes—this work can all be done on the same job, and

thus the contractors can make a start at once if they so wish; of course a record of all field work is required, and the results should all be put in the grade book. For setting slope stakes the only satisfactory method is with the Leveling instrument, though for comparatively smooth ground and light work, there are various devices for setting slopes which involve much less work, and are sufficiently accurate for use.

CENTRES AND GRADES.

Most of the work for railroads in construction consists in setting "centres" and "grades;" for the former, in nine cases out of ten, the line can be run in without an instrument, if the known points are convenient; the Tangent Deflections are useful for running curves with only the chain and rods for lining; for approximation there is a very convenient method of computing angles and distances (measured as arcs) which it is well to be familiar with in the absence of all "pocket-books." At one hundred feet distance three-hundredths of one foot subtends one minute of arc. Strictly speaking it is twenty-nine one thousandths instead of three one hundredths. At the same distance one foot and three-quarters subtends one degree of arc, but one and eight-tenths can generally be used. With this once fixed firmly in the mind, mental computations can be made with the greatest ease. As an example of this let it be required to find Tangent and Chord Deflection for 100 feet chord, and for 60 feet chord, and ordinate at centre of 100 feet chord for a 5° curve: $5\times1.8=9.00'$ for the Chord Deflection, and 4 5′ for the Tangent Deflection 100 feet chord: $4.5\times0.6=2.7'-2.7\times0.6.=1.62$ Tangent Deflection for the 60 feet chord, and $\frac{1}{4}$ of the Tangent Deflection for 100 feet chord $=1\frac{1}{8}'$ for the middle ordinate. These values are all in excess, and if the deflections are to be used for running the curve more than one station, the value $1\frac{3}{4}'\times5=8\frac{3}{4}'$ should be used, and this is in error only about $\frac{3}{8}$ of an inch. A great many other computations may be thus performed mentally, and the work already done checked by these approximations, and the real blunders found.

QUALIFICATIONS FOR LEADER.

There are many ways of doing most kinds of field work, and many methods are described in the books under various heads—but a good knowledge of geometry and trigonometry, and possibly a little familiarity with analytic geometry, combined with a cool head, and an appreciation of the external circumstances, will en-

able a man, after a limited experience, to become competent to take charge of a party in the field; as far as the mere theory of the operations is concerned—but a knowledge of human nature and sound judgment are required to give satisfactory results.

CULVERTS AND MASONRY.

We would say a word about the staking out of culverts and masonry, and will begin with a hint about box culverts. On masonry of this class it is well to put in four stakes on the lines of the face of each wall, one at each end of each line, and two stakes, one on each end of a line terminating the culvert at the proper distance out, found as in slope stakes. These stakes must all be placed outside of the trenches, and should be at such a distance from the work that they will be safe during the construction.

BRIDGE ABUTMENTS.

Bridge abutments on shore can be given in the same way, and if in the water by parallel lines, or sighting frames made out of strips of wood. Piers can be located by sights on shore, or as they are commonly termed "ranges."

EARTHWORK MEASUREMENT.

If earthwork is to be measured in a "borrow pit," the best way is to run out two sets of lines at right angles over the ground, denoting distances in one direction by letters, and in the other direction by numbers, and taking the levels all over the ground denoting the stake by both letter and number, and then every month as the work is done, these stakes can be replaced and the levels taken again. The bounding lines of this system should be carefully put in, and the stakes may have permanent "sights" put up over them; in this case the stakes of the system can be replaced without a transit. Of course the bounding lines should be wholly outside the work and there can be little trouble in taking care of the work in this way.

RETAINING WALLS.

Retaining walls are very usually set out by stakes, but "sighting frames" outside the wall and in line with it are to be prepared, if the height is not too great.

TUNNELS.

Underground work in tunnels is usually kept in line and grade by points on the roof; their stability and permanence are much greater than if given on the bottom of the tunnel. In rock work where stakes can not be used, chisel marks are made to serve as points. Such work requires less frequent attention, but is more important.

RESPONSIBILITY OF ENGINEER.

And now in closing, let us add a word as to the responsibility resting upon the engineer when setting out work.

Few beginners appreciate the necessity for correct work, and do not realize that a blunder undetected may cause a loss to the contractor of a great deal of money, and that if he, as the company's authorized agent, makes a mistake in his work, the company may become liable for many times his salary, and that his discharge is a very small amelioration of matters which he has mixed. Pecuniary responsibility must be fully appreciated in order to have accurate work done.

Mistakes in work are not only discreditable but they are dishonorable, and to the feelings of the suffering party they seem criminal. Now as man is liable to error, work must always be in some way checked, and a mistake which is discovered by the maker in time to be rectified by him before any damage is done is in no way discreditable, provided however that it does not happen too often, and that the same class of mistake is not made the second time. Nothing gives a contractor less respect for the engineer than finding his mistakes, even if they have caused no damage.

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REGULATIONS

FOR THE

ENGINEERING DEPARTMENT

DURING

CONSTRUCTION.*

BY WM. F. SHUNK, C. E.

I. ORGANIZATION.

1. The chief engineer will have exclusive control of this department.

2. He may be aided by a consulting engineer, without executive powers, and an associate engineer, acting under his immediate direction, to whom all official communications from subordinates should be addressed, and whose orders concerning the work, or matters thereto appertaining, shall be received as authoritative.

3. The associate engineer shall be aided by such a staff of division engineers, principal assistant engineers, draughtsmen, clerks, and other helpers as shall be approved by the chief engineer.

4. Each division engineer shall have charge of the construction of about thirty miles of road, in sections approximating one mile long and subdivisions composed of from six to ten sections.

5. Principal assistant engineers may be appointed to special charges, such as important structures, the compilation of records, the preparation of plans and the like. Where such charges fall within the territorial limits of a division engineer, strict definition of responsibility will be made and hearty co-operation expected.

* South Pennsylvania R.R.

6. Division engineers shall have power to employ one draughtsman for the division headquarters office, and such resident engineer, inspectors, time keepers, and other helpers on the line of road as may be necessary for the proper conduct of the work for which they are immediately responsible, subject beforehand to the approval of the associate engineer; and to suspend or discharge such employés for sufficient cause. The power of removal should be exercised discreetly, and seldom without reference to the associate engineer.

7. Each resident engineer shall be aided by one rodman, competent to use transit and level, two tapemen, and one axeman, until the line is cross-sectioned. Thereafter one tapeman may be dispensed with. Special assignments of force will be made, when necessary, to divisions which include large tunnels. Each resident engineer shall have power to appoint, suspend or remove his own subordinates, subject to the approval of the division engineer.

8. Good discipline and orderly management require that all official communications, verbal or written, shall pass from the superior to his immediate subordinate, or from the subordinate to his immediate superior. Should any emergency necessitate a deviation from this rule, the party intermediately concerned should be informed of it.

II. PREPARATORY WORK.

1. First of all, division engineers shall cause the centre line of location on their respective divisions to be accurately retraced, established and test-leveled.

2. This done, they shall furnish promptly to the associate engineer a map in duplicate of their respective divisions, scale four hundred feet to an inch, one copy to be on mounted drawing paper, the other on tracing linen, showing the centre line and proposed right-of-way boundaries in red; intersected and adjacent property lines with names of owners, political boundaries, contours, streams, roads, woodland, buildings, and other objects proper to a working map, in black; also a profile, similarly duplicated, to "Plate A" scale, upon which shall be marked the estimated quantities in each cut and fill, the character of the material, the alignment corresponding to map, and the proposed grade line, the latter to be penciled on the paper duplicate and drawn very finely on the tracing in red, with its rates per centum and elevations of change points clearly figured.

3. The paper copy of each of said duplicates will be returned, with

such alterations as the chief engineer may think proper to make or approve, and endorsed with his approval, or that of his associate, to the division engineer, who shall place them on file in his office.

4. Thereafter no change of line or grade will be permitted, excepting upon compliance with the like form of procedure, namely: The submission of duplicate drawings of the change proposed, and the return of copies approved by the chief engineer or his associate.

5. Division engineers shall cause to be prepared for each of their Residents copies, from the foregoing approved map and profile, of the respective subdivisions, and also a pencil record of location, in the following form, to be called the "*Location Record, Div. No. . . Subdiv.' No. . :*

Sta.	Deflec.	Alignment.	Mag. Course.	Gradient.	ELEVATION.		Cross Sections.	Remarks.
					Ground.	Grade.		

6. In the station column, transit points should be marked with a circle, as usual, and turning points inclosed with a triangle in addition to the circle. Directly below every turning point record the note should be made, "B. S. to . . . ." indicating the backsight point; and in the deflection column should be recorded the total deflection, at each turning point, from the range of backsight to that of foresight. By means of such a record the line can in future be retraced, not only over the same points, but, failing one or more of them, with the same angles used on the establishment of location.

7. The alignment column must show the calculated course and the length of each tangent, thus; N. 64° 35′. W.—3,972 feet; and the degree, length, angle, and apex distance of each curve, thus: 5° C. R. (or L.)—650 ft.; angle, 32° 30′; A. D. 334 feet.

8. The column of remarks should contain notes of benches, land, stream, timber, and road lines, and other matters of interest relating to the line or the work to be constructed. The cross-section columns should be reserved. Stations should be entered on every third line of the book only, thereby recording about eight hundred feet per page, to provide for subsequent additions.

9. The original book from which the copies are made, should be retained by the division engineer.

III. RIGHT OF WAY.

1. Division engineers shall next cause the necessary surveys for right-of-way to be made, and maps thereof to be prepared on "Topography" paper, scale two hundred feet to an inch, showing the plan of land to be taken, the contents of severalties in acres and hundredths, the Township, County and State wherein situated, owners' names, road crossings, streams, buildings, woodland, meridian line, and other objects needful or useful in such an exhibit.

2. These maps shall be consecutively numbered, and shall have a blank margin two inches wide on the left edge, that they may be bound in volumes for the Company's archives. When more than one property is represented on a sheet, the severalties shall be designated by the sheet number and an annex letter, "*a*," "*b*," etc.

3. Division engineers shall furnish to the land agent appointed by the Company, when requested by him, a tracing from these maps numbered and sub-lettered to correspond with the original, together with a description of each property, for incorporation with the deeds.

4. Currently with the purchase of right-of-way, or as soon thereafter as more important service shall permit, division engineers shall cause the boundaries of the Company's property to be marked by corner and line stones, or other endurable monuments. This should be done before ground is broken, if possible, and said monuments should be carefully maintained during the progress of construction.

5. Division engineers, in laying out proposed land purchases on the maps, prescribed in (II., 2,) should provide amply for station grounds extra tracks, borrow pits, and spoil banks, and call attention thereto by explanatory notes on said maps.

6. The lay-out shall be for a double-track railroad, tracks thirteen feet between centres. Sixty feet shall be the minimum width taken in any case, without the express approval of the chief engineer or his associate; and as a general rule, a berm twelve feet wide on each side of the road formation shall be included in the Company's right-of-way.

7. The Company's boundary line shall generally be parallel to the centre line of the railroad, and right-of-way widths shall change by jogs square to said centre line, excepting at the bounds of severalties, where changes of width should be located, whenever convenient, and conformably to existing land lines.

IV. FINAL PREPARATIONS FOR CONSTRUCTION.

1. The centre line having been established and test-leveled, agreeably to (II., 1,) it should now be gone over with the level very carefully, setting stakes at "grade" points and at changes of surface necessitating additional cross-sections, marking the variations on the backs of centre stakes, noting the elevations of roads, stream beds and high water lines, and making new bench marks at intervals of about one thousand feet, preferably near the sites of structures and heavy cuts, where most needed, and out of the way of probable disturbance.

2. Then traverse the line again with the transit, over the old points and with the same deflections recorded on the establishment of the location if found correct, trueing the interpolated stakes last set by level, and placing and referencing centre plugs at "grade" points, grade summits, and wherever else they are likely to be convenient during construction.

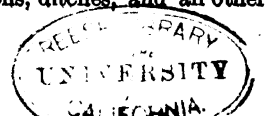
3. Any discrepancies in line or level with former work, discovered during these operations, should be reported immediately to the division engineer.

4. Slope staking follows next in order. Division engineers shall personally ascertain the probable character of the material in excavations, boring or sinking test pits when, in their judgment, the importance of such knowledge warrants it; and they will instruct their subordinates as to the formation slopes to be adopted in every questionable case.

5. In addition to setting the usual grade and slope stakes, the ground should be cross-sectioned a sufficient width to provide for possible slips, further changes of slope, or a four-track road. Stakes or plugs should be firmly driven at these limit points of observation, whether the work be in cut or fill, in range crosswise with the centre and slope stakes, which should always be placed at right angles to the road axis, their distance from centre line and elevations as to grade being noted for record, and for use if needed subsequently. They may prove to be very convenient during construction at cuts through uncertain material, and when measuring for estimates.

6. On hillsides where the road bed is partly in excavation and partly in embankment, its dimensions shall be compounded of those given in the standard drawings for excavation and embankment.

7. Borrow pits, grading at stations, ditches, and all other incidental



excavations, should be staked and recorded with the same exactness as the road formation. They should be worked in a regular manner, so as to be readily measured, and present a shapely appearance after completion.

8. Masses of rock found in cuts and isolated from the slopes should be measured and recorded in the proper books and shown in the cross-section drawings.

9. The accurate establishment and subsequent protection of tunnel lines should claim the early personal attention of division engineers. They will be duly authorized by the chief engineer to acquire the temporary use of ground for observatories and guide lines outside the Company's right-of-way, when expedient to do so.

10. The alignment and levels at tunnel sites should be retraced and repeated until the possibility of error is reduced to an unimportant minimum. Such work is best done early in the day, while the air is equable and free from refractory currents.

11. Resident engineers shall personally attend to the staking of all foundation pits. Before masonry is started, the division engineer should inspect such pits, and assure himself by sounding or otherwise, that they are of sufficient depth and firmness. When judged prudent, the bottom earth should be compacted with rammers.

12. Currently with the foregoing operations, the location record, prescribed in (II., 5,) should be perfected by the addition of the cross-section notes, and the latter line and level notes, and all permanently entered in ink.

13. Division engineers should traverse their charges weekly. Resident engineers should be constantly on the line by day, excepting when foul weather or important office work prevents. They should give grade and line weekly, and whenever asked by contractors. They are thus in the way of correcting errors at the outset, of instructing foremen seasonably to prevent errors, and of ascertaining the various character of material for estimates, to the furtherance of the work and the due service of the contractors, who should not have reasonable ground for dissatisfaction with this department.

V. STRUCTURE PLANS.

1. The chief engineer will cause standard drawings of the road formation and ordinary structures to be furnished to each division office. Di-

vision engineers shall supply duplicates of these drawings to their resident engineers, as needed.

2. Division engineers shall cause necessary modifications to be made in masonry plans to adapt them to various localities, altering the flare or length of wing wall, for example, to fit irregular ground, skewing for oblique channels or roads, sizing for heights intermediate to those provided for in the standards, and the like; but the elevations and square widths of bridge seats shall not be altered except by warrant from the chief engineer or his associate.

3. Special instructions will be given as to structures on steep inclines and skew openings sharper than forty-five degrees from the centre line.

4. Plans modified by division engineers, and also the standard structures which they propose as being anywhere suitable, shall have the approval of the chief engineer or his associate before the work is laid out.

5. Where special structures are required, such as viaducts, large bridges, or other exceptional work, not provided for in the standard plans, the division engineer shall cause the ground to be surveyed and mapped to five feet contours; scale, ten feet to an inch, with corresponding profile, and submit the same, accompanied by illustrative notes and such suggestions as he may think proper to add, to the associate engineer, who will, thereupon, cause a plan to be made, or give orders for its making to the division engineer. Exhibits of this kind should include high and low water marks, character of bottom or sub-soil, and, in the cases of road-crossings, a profile of the same for five hundred feet each way.

6. All plans of railroad buildings shall originate at the central office, and copies thereof will be furnished by the chief engineer or his associate, with suitable instructions, to the division or principal assistant engineer charged with their erection.

7. Copies of all plans prepared by division engineers for their residents shall be preserved in the division office.

VI. FIELD AND OFFICE RECORDS.

1. Resident engineers shall prepare a series of cross-section drawings, including the tunnels, of their respective subdivisions, in bound books of uniform size furnished for that purpose, showing the original surface of

the ground as widely as observations extend, the slope staking for road formation, the staking for incidental excavations, the proposed formation lines, and the computed quantities before grading, in India ink; copies, or written abstracts, of which cross-sections they shall transmit to the division engineer from time to time as they are made, marked with the name of the division and other distinguishing particulars.

2. On completion of each road-section the resident engineer shall amend and perfect his original cross-section book by drawing thereon, in permanent red, the actual formation as completed, showing the parting lines between various classes of material, and the actual quantities of said various classes as contained in the final estimate of the graduation of said road-section; together with a statement of the cost of said graduation to the contractors and the Company, which amendments the division engineer shall thereupon cause to be incorporated in his own copies of the cross-sections, after revision by him, and shall, when requested, or on the completion of the work, transmit the originals to the associate engineer, endorsed with his approval.

3. The statement of cost to the contractor should comprise, as nearly as can be ascertained, the value per item, and the amount of labor, material, use of tools and machinery, superintendence and sundries, distributed and assigned in such detail as information on hand shall warrant. The statement of cost to the Company should be a summary of the final estimate.

4. The cross-section books will be paged with consecutive numbers; no erasures shall be made in them, nor shall any leaf be removed therefrom for any cause whatsoever. If errors occur cancel the page in such manner as not to obscure the errors, and use the next page.

5. Resident engineers shall also prepare a series of masonry drawings, on white paper sheets of uniform size furnished for the purpose, in which all such structures, including drain pipes, shall be represented on a scale of four feet to the inch, or eight feet to the inch, as the division engineer may prescribe for structures of various magnitude. Such drawings shall show the said structures in plan, elevation, and section as actually built, inclusive of foundations, foundation pits, substructure if any, grade line, and elevations of leading details. There shall be also a legend on the drawings of each separate structure, stating clearly the actual quantities of the various classes of work included in the final estimate, and a summary, such as is prescribed for graduation, of the actual cost to the contractors and to the Company.

6. On the completion of each subdivision said cross-section, tunnel and masonry drawings shall be transmitted to the division engineer, and by him, when so requested, after correction therefrom of the copies on his files, transmitted, with his approval affixed, to the associate engineer.

7. Each drawing of the two sets described above shall be exactly localized, in its title, with the name of the division, subdivison, section, station and plus.

8. Each division engineer, at or before the time of transmitting his first monthly estimate, shall send to the associate engineer a complete profile, on mounted "Plate A," paper, of his division, showing alignments, gradients, and other full details as finally established for construction.

9. Then, and thereafter with each monthly estimate, he shall forward to the associate engineer tracing exhibits, or written memoranda, indicating the condition of the work at the date of said estimate, from his progress profile, in order that the progress profile in the central office may be supplemented to match.

10. All progress profiles shall represent the work done during each month in transparent washes of color, as follows:

January.....*Carmine.*	July,.....*Scarlet.*
February.....*Green.*	August.....*Dark Green.*
March.....*Yellow.*	September.....*Orange.*
April..... .....*Cobalt Blue.*	October.....*Purple.*
May,.....*Burnt Sienna.*	November.....*Burnt Umber.*
June.....*Black.*	December.....*Gray.*

11. Division engineer shall cause to be prepared, on mounted white roll paper, a complete map and profile of his division, horizontal scale four hundred feet, vertical scale forty feet to an inch, both on the same sheet, showing the centre line, grade line, and land lines of the road in red, streams in blue, brick and frame buildings in carmine and burnt sienna respectively, faintly colored; all other details in India ink, with ten feet contours finely drawn, each even hundred slightly heavied, and the outer limits of road formation—that is to say, the crests of cuts and the toes of fills—indicated in plan by dotted lines. This document to lie on the stocks in the division office, gradually perfecting, and finally including all the company's lands and buildings, together with such supplemental plans, to larger scales, as the chief engineer shall order, of town properties or particular reaches of the road, whereupon it shall be filed

in the central office as a permanent record. The above map should embrace, if possible, all the topography obtained during the surveys within one mile on each side of the located line, and should be neatly and accurately executed.

12. Each division engineer, contemporaneously with the foregoing map and profile, shall cause to be prepared a complete record and description, by sections, of the finished roadway on his division, after the following general form, to be furnished from the central office:

Div. No....., *Sec. No.....*

Sta.	Dis.	Def.	Allign't.	M. C.	RT. OF WAY.		ELEVT.		Gradient.	Width of road-way.	CROSS SECTIONS.			GRADUATION C. Y.					
					L.	R.	Ground.	Grade.			L.	C.	R.	Rock.	Loose R.	Earth.	Embk.	Found.	Misc.

MASONRY CLASSES C. YDS.					DESCRIPTION OF			
1.	2.	3.	4.	Misc.	Mas'y structures.	Bridges and viaducts.	Miscell.	Remarks.

13. To the record of each road section shall be appended a summary or the final estimate for said section, as paid by the company, and the column of remarks shall contain the miscellaneous notes from office records previously compiled, together with such other information, as to boundary monuments or plusses, bench marks, foundations and sundries, as may be of use on future enlargements of the road-bed and right-of-way.

14. Division engineers shall require periodically from their subordinates the data necessary for the compilation of this record. On its completion they will entitle it, adding a brief description of the division, its locality and terminal points, and transmit the record to the associate engineer, endorsed with their approval, for the company's archives.

15. Resident engineers shall keep a series of field books, to be called "Construction Notes," one of which shall be always borne about them, and used for recording their daily doings, noted on the spot, with day, date, and locality specified. In these books all field operations relating to the work of the contractors shall be calculated and entered, such as the giving of line or grade, setting or re-setting cross-section stakes, laying

out tunnels and structures, measurements for estimate, dimensions and depths of foundation pits, coffer-dams, elevation of bridge seats, verbal orders given to the contractors or their agents; in short, all their transactions and observations on the line, together with a diary of office work. The current volume of this series should be delivered to the rodman for his use, if charged with separate field duties, in case of the absence or disability of the resident. These books will be numbered consecutively and plainly marked, on the outside, with the names of the division and subdivision, and the periods of time covered by them. They shall be preserved with great care, and turned in to the division engineer on the completion of the respective subdivisions, or when called for.

16. Resident engineers shall use and preserve bound books, to be furnished from the central office, instead of the common scratch-blocks, for office calculations, drafts of estimates, all figuring of exhibits or return called for by the division engineer, and statements by others entitled to them, with day and date noted at the time of each entry. These books shall be called "Blotters," and shall be numbered and marked as prescribed for "Construction Notes."

17. Division engineers shall keep similar books for the record of their daily doings in the office or field, and these, together with those of the resident engineers, shall be delivered by them to the associate engineer, on the completion of the work, or when called for. "Construction Notes" and "Blotters" shall be left in the original manuscript, and not inked over in pencil. If errors occur, cancel in such manner as to leave them legible, and insert the corrected work further on, noting the former as erroneous, and referring to the latter.

18. Division, principal assistant and resident engineers shall preserve press copies of all official written communications sent out by them, in bound volumes, to be properly titled and indexed, and handed into the central office on completion of the work. They shall indorse and preserve all like communications received to the same end.

19. Principal assistant and division engineers will be supplied with copies of the contracts and specifications relating to their charges. They may be commissioned by authority of the chief engineer to negotiate contracts for labor, material or right of way in special cases, but all such contracts must be conditioned on the approval of the chief engineer, signed by himself or other immediate representatives of the company, and the orignals filed in the central office.

20. All subordinates of this department responsible for the right conduct of work, shall hold the contractors to its timely and proper execution, in accordance with the terms of the agreement and the requirements of the specification. They should not only be vigilant to prevent any hindrance to the contractors, but active and prompt to keep well in advance of them, so that there shall be no just cause of complaint for lack of stakes or instructions. All official communications to the contractors should be clear and explicit, and respectful in tone, and should be recorded at the time, as herein elsewhere directed. Orders and instructions shall be given in writing, when asked for by any contractor, sub-contractor or foreman.

21. Should it appear, in any case, that the conditions of a contract are likely to fail of fulfillment as to time of completion or otherwise, the associate engineer shall be seasonably informed of it, with a statement of the causes. Any radical remedies provided for in the contract must be administered by the chief engineer only, or by express authority from him.

22. All maps, drawings, papers and books should be clearly marked with titles, numbers and characters, and orderly bestowed and catalogued for ready reference in the offices of this department. Division engineers should see that their subordinates conform to this rule, and they should at frequent intervals inspect the instruments furnished their subdivisions, to make sure that they are kept in adjustment and not ill-used.

23. No original records shall be permitted to leave the respective offices, excepting as herein prescribed. Other departments or agencies of the company entitled to information from this department must be served by copy only, and not by the original drawings, sections or records, unless the chief engineer expressly warrants a deviation from the rule.

24. All regulations herein contained for the government of line engineers proper shall govern principal assistants and others in the special service of the department, to whom they are cleary applicable.

VII. INSPECTORS AND TIME KEEPERS.

1. Division engineers will be authorized, when it appears proper to the chief engineer, to employ inspectors for important structures. Such inspectors shall receive orders from and report directly to the resident en-

gineer. Division engineers will instruct their residents as to the duties of inspectors.

2. Each division engineer may, by like authority, employ a general time keeper, whose duty it shall be to keep a correct record of the labor and machinery employed on the work, properly classified and located, the wages paid, materials expended, and other notes concerning the progress of the work and the contractor's outlay.

3. The time keeper shall act under the immediate orders of the division engineer. Resident engineers and their subordinates should be instructed to co-operate with him, and he shall have power to employ additional help, subject to the approval of the division engineer, in the event of their assistance proving inadequate.

4. He should report weekly to the division engineer, and hand in a monthly statement of the force account of each subdivision, properly distributed, for reference by the division engineer of the residents.

5. Resident engineers and their subordinates should be so constantly on the line as to obtain an independent force account, approximately correct, for themselves. This they shall do, for comparison with that furnished by the division engineer, should a general time keeper be employed ; and, in case of any unaccountable discrepancy, call his attention to it.

6. Division engineers shall make monthly returns of force accounts, with their monthly estimates to the associate engineer, after a form provided by the central office.

7. Division engineers shall keep a book of force accounts, showing the items properly classified and distributed, and will compare and harmonize notes with the Residents when making up the Road Section Records herein prescribed (VI. 12).

VIII. ESTIMATES.

1. On or about the 27th of each month, resident engineers shall take measurements and make an estimate of the work done on each section of their respective subdivisions during the month current, statements of which estimates they shall prepare in duplicate on prescribed forms, one copy to be retained, the other to be delivered to the division engineer not later than the first day of the month following that to which they refer.

2. Division engineers shall prepare like estimates of the work done on each section of their respective divisions in quadruplicate and send three copies, duly authenticated, to the associate engineer, not later than the fifth day of the month following that to which they refer, accompanied by a force account, a recapitulation of work after such forms as may be provided, and abstracts for the progress profile herein before described (VI., 9). One copy of the estimate sheets and accompanying papers, excepting progress data, will be retained on his office file.

3. Quantities greater than those due to the net measure, as defined by the slope staking, the masonry plans or prescribed tunnel sections shall not be allowed in either the monthly or the final estimates; provided, however, that any extra expense incurred shall be clearly the result of slovenly conduct or violation of orders. If unsuitably slope-staked, if drawings are erroneous, or if slips occur in cuts and falls in tunnels from causes not reasonably to have been forecast and prevented, the extra work done may be covered by estimate, under instructions from the chief engineer.

4. In classifying estimates, the quality of masonry and the character of material removed, as described in the specifications, shall be regarded exclusively of all other considerations. If any case of losing merit occurs, employés in this department must bear in mind that such case is for the judgment and the action solely of those who pay the money, the engineer's duty being rigorous adherence to the requirements of the contract and specifications.

5. No employés of this department shall be interested in any contract, or in the furnishing of contractors' supplies on the line of the road, or in any business connected therewith, excepting that of the Company.

IX. ACCOUNTS, SUPPLIES AND SUNDRIES.

1. The pay-rolls and expense accounts for each month shall be prepared by the division engineers and transmitted, with their endorsements, on or before the fifth day of the month following, to the associate engineer.

2. After approval in the central office, checks will be sent to the division engineers for each individual to whom payment appears to be due, and the receipted pay rolls and expense vouchers shall then be returned to the associate engineer.

3. Division engineers shall book the salary and expense accounts of their respective divisions in the usual form, and shall report all discharges, appointments and transfers to the associate engineer at the time of such transactions.

4. The fixed salaries of the employés of this department shall be in full for all service and personal expense, excepting necessary outlays on the Company's business, for transportation and subsistence, by division engineers or their draughtsmen when called away from the Division Headquarters, and by resident engineers or their subordinates when called away from their Subdivisions.

5. Division engineers shall make formal requisition on the associate engineer for necessary equipment and supplies. They shall keep a record of all company property in their charge, and make report thereof quarterly, with inventory of articles on hand at date of previous report, received since, expended, in what manner or service, and on hand at date of current report, adding explanatory remarks.

6. Under the head of incidental expenses shall be included, and itemized, minor outlays for stationary and printing, office rent, fuel, lights and attendance, tools and repairs thereof, postage, telegraph and express charges, messengers on special errands requiring certainty and dispatch, and such small stores, needed in the progress of the work, as can best be obtained on the ground. In these matters, and in the conduct of their charges generally, division engineers are expected to practice a watchful and rational economy and to exact it of their sub rdinates, Incorrect estimates, slovenly records, laziness, drunkenness, erroneous field work, bungling use of instruments to their injury, squandering of road supplies for private account and the like should be followed by quick riddance of the culprit.

7. Offices should not be lounging places, and great care must be taken that no unauthorized persons have access to books, papers, or other information relating to the work.

8. No person appointed to or discharged from the company's service in this Department, shall be allowed expenses to or from the field of service.

X. MISCELLANEOUS INSTRUCTIONS AND SUGGESTIONS.

1. In slope staking, when material is doubtful, stake for rock. In such cases where earth cuts are started vertical, have a force to follow closely with trimmed slopes, to avoid irregular breaks and slips. Set side stakes

every fifty feet for trimmers. After stripping rock restake for it. Leave a berm of four feet between foot of earth slope and crest of rock in mixed cuts.

2. All curves should be slope-staked at intervals of fifty feet.

3. Where cut is in excess, have it wasted regularly along the convexed side of curve in adjacent fill, unless the possibility of flattening the curve in future makes it expedient to waste on the concave side. Waste symmetrically on tangents; if single track, on double track side,—subject to the condition that no overhaul shall be required and no increase of masonry, except by warrant from the central office.

4. Where fill is in excess on single track, first double track the adjacent cuts for a supply, if earth, and within overhaul limit. Should more material be needed, widen earth cuts to their utmost, leaving in every case room for berm ditch and additional four feet for fence berm.

5. Waste no material above grade unless imperative and authorized by the division engineer. Where material is permitted thus to be wasted, leave in every case a berm of not less than ten feet, and additional allowance for future extra track.

6. Be vigilant to prevent tresspass on adjacent properties in making side ditches, spoil banks, or otherwise.

7. Side and berm ditches should be opened in advance of graduation and kept open. Material from berm ditches should be ridged up regularly on down hill side; that from side ditches deposited in embankment. See that the outfall from ditches in cuts is turned aside so as not to scour the fills.

8. Where stream channels are changed the new channel should be side sloped, and a berm of twelve feet, with allowance for future extra track, left between its crest and foot of embankment.

9. On bare slopes, to be embanked, plow the ground lengthwise before filling in, and on very steep hillsides excavate terrace benches to hold the embankment.

10. Examine embankment sites for springs and have them carefully drained clear of the formation, by ditches filled with broken stone or cobbles.

11. Finish all earth or mixed embankments, full width at top and four per centum of the record center height above grade for the reception of ballast; rock embankments, two per centum. This is tentative, and subject to modification. It is believed to be sufficient allowance for embank-

ments made in layers or with scraper, and approximately correct for heavy dumped work on good bottom, which, advancing more slowly, must needs have gotten to its bearing in some measure before completion. Division engineers are invited to give their past experience on this point, and also to profit by their present opportunity for more knowledge concerning it.

12. In rock cuts see that no large masses, dislodged by blasting, are allowed to remain on the slopes or overhanging them. Examine all such masses with bars, and, where liable to be washed or frosted down, have them removed and duly entered in the estimates.

13. Require rock cuts and tunnels to be taken out full width and depth at once, and suffer no bottoming to be left over except by special permission of the chief engineer, in tunnels only, for the purpose of drainage during construction.

14. See that the road is graded true to line, and as staked out; that material needed elsewhere is not wasted at mouths of cuts; that side slopes in excavations are plane surfaces, not convex; that embankments are carried out the full width due to the slope staking at whatever level built; that their slopes are plane surfaces, not concave; that they are built in layers back of all abutment and culvert walls; that the centres of arch culverts are allowed generally to remain until the embankment has been carried by them; and, if removed, that the embankment is built in layers a proper height above crown of arch.

15. Approaches to crossings, in excavation or embankment, should be graded not less than twelve feet wide on top, and up to the height of top of rail—say two feet above the grade of formation; they should ramp or slope at a rate not exceeding one in ten, and be level a sufficient distance each side of the railroad to prevent the possibility of stone or timber trucks stalling on the track.

16. Meeting grades should be rounded off with vertical curves at least six hundred feet long; and as much longer, especially in the case of pockets, or cylindrical grades, as economical conditions will permit. Special instructions will be given on this subject.

17. Be cautious not to allow full measure in monthly estimates before the work is settled, surfaced and trimmed; a safe reserve should be held usually for such items.

18. In retracing line during construction, or after graduation, use the original turning points established on the final revision of the line.

19. Timber and brush should be cleared the full width of right-of-way, and valuable timber piled up along the right-of-way, and saved for the company, where the clearing is done by the contractor. Trees on abutting properties whose accidental fall might encumber the track, should be legally condemned and felled.

20. Avoid small openings in the roadbed, using box or arch culverts preferably.

21. The road-bed should be trimmed to a crown of three inches above grade in the middle, to promote lateral drainage under the ballast.

22. Sound doubtful foundation pits with an iron rod, and make sure of a good bottom. Drain them when feasible. Where not liable to wash or to subsequent exposure, two feet of gravel, shingle or broken stone, well rammed, makes an excellent foundation course.

23. See particularly to the deep and safe founding of walls and curbs at the outfall end of drainage structures.

24. Before sizing opens for culverts and bridges search the water down stream for some point where flood volume is well marked, and work by that.

25. Observe and report streams suitable for water supply.

26. Insist on specification requirements in masonry. Make it clearly understood that no excess of neat work beyond scale plans will be estimated. No crushable chips. No grouting unless specially authorized. Flush up solid instead, with mortar as stiff as it will work readily. Good bond imperative, and to take precedence of outside looks.

27. Clear away the surplus stone and wreckage from masonry sites after the jobs are done; and before the completion of each section, have blasted rock and all other cumber accumulated during construction removed from adjacent properties and highways.

28. In establishing outside tunnel lines by daylight, the best time has been found to be just after sunrise, and the best sight pole a half-inch round iron rod painted white. Plummet lamps, on clear calm nights, have given better results than sight poles by day, being distinctly visible at long distances.

29. To transfer line down a shaft, set transit point at a distance therefrom of about twenty-five feet, from which point, with a long foresight, two staples or other guides, may be ranged on the side timbers overhanging the pit, and the centre line thence plumbed to the bottom with fine

copper wires, bobbed as heavily as they can bear, the bobs immersed in water. It has been necessary in some cases to box in the wires, to protect them against water and air currents. Careful manipulation, patient and repeated observations, and a discreet average of them are required for a correct transfer.

30. The range at bottom must be transferred to wooden roof plugs, in which eyescrews, staples or other suitable fixtures are ranged, and from which plummet lamps may be hung when required.

31. Bench marks are established similarly in the roof, being stubs of steel fastened into holes or chinks, the elevations of which are obtained by means of a reversed rod. The levels may be transferred from the surface with a steel tape or wooden rods.

32. All centre points and bench marks should be placed out of danger from rocks thrown by blasting.

33. Standard measures should be made at the outset by which to test, from time to time, the tapes, level rods and other field measures used on the work, as it is important that these measures be uniform, and guarded against change.

34. For leveling underground a target with a diamond-shaped opening in it has been found convenient, one of the diagonals of said opening being horizontal. The rod is plumbed with a portable level bubble made for the purpose, and a light is held behind the target at the time of observation.

35. Division engineers will supplement these general memoranda as to tunnel surveying, and will find room for their ingenuity in expanding and diversifying them to suit various practice.

36. Require tie-contractors to pile the ties regularly, both ends visible, and spaced suitably for inspection, within not less than fifteen feet nor more than forty feet from the centre line of double-track road bed, and not over two feet below grade, when the nature of the ground will admit of compliance with this rule. When it will not, then require them to be delivered and piled where they can be conveniently got at by the tracklayers.

37. After tracklaying, and before opening the road to traffic, a flat car should be run its whole length each way, with templates, fixable crosswise, for testing the clear width of rock cuts and dimensions of tunnel sections. Every point encroaching on the standard section should be

marked with red paint from a large "whitewash" brush, and removed promptly by a floating gang.

38. The terms "grade line" and "grade," as herein used, refer to the surface of the road bed, at the established profile grade; that is to say, to the bottoms of cuts and the tops of fills, as prepared for the reception of any crowning to promote lateral drainage and of the railway proper, or superstructure, comprising ballast, ties and rails. The term subgrade is omitted as superfluous and confusing, and is not to be used on this road. The elevations of bridge seats, bridge structures and their parts, foundations, piers, trestle-work, rails, cross-ties, and all other details requiring such reference shall be referred to the elevation of "grade," by plus and minus signs.

39. Some of the rules contained in this article are intended to be suggestive rather than mandatory—practical hints and instructions. Division engineers and all others concerned are invited to report any discrepancies, errors or deficiencies, which they may observe, either here or elsewhere, in the present compilation, and to suggest what they judge to be improvements, corrections or useful additions. Regard any rules as invalid which may appear to conflict with provisions in the contract and specifications, or to call for expense not therein contemplated.

WM. F. SHUNK,
Associate Engineer.

APPROVED:

ROBT. H. SAYRE,
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HOWE TRUSS BRIDGES.

In ENGINEERING NEWS of April 26, 1890, a double page lithographed inset was published, showing 27 strain sheets and sizes of members for Howe truss bridges from 30 feet to 150 feet span, sent by Chief Engineer A. A. Schenck, of the Oregon Pacific Railway Co., and which we believe to be safe and careful designs, in accordance with the latest and best practice in wooden bridge construction, which for a long time to come will be an important department of American engineering work, although one of continually decreasing relative importance.

One fact we should especially call attention to, that these bridges are designed for a region where very long timber is readily obtained, and is no more expensive than short timbers, so that the sections given for lower chord would be much weaker in proportion to regions where equally long timber was not available. The great difference in the amount of iron required when the rods are upset or not upset, is curiously shown in the table of data herewith reprinted:

TABLE OF DATA.

No. of Span.	Assumed loading per foot.			Total load per foot. lbs.	Estimate of Quantities.			W. Iron. Lbs. Rods upset.
	Trusses lbs.	Floor lbs.	Train lbs.		Timber Ft. B.M.	W. Iron lbs.	C. Iron lbs.	
1	360	500	5,060	5,620	10,165	2,170	,970	
2	360	"	5,060	5,920	6,750	1,930	1,210	
3	400	"	4,600	5,500	13,358	2,960	1,070	
4	400	"	4,600	5,500	9,362	3,280	1,550	
5	450	"	4,200	5,150	19,025	5,610	2,880	
6	450	"	4,200	5,150	12,861	4,710	2,830	
7	540	"	3,860	4,900	22,785	6,790	3,660	
8	540	"	3,860	4,900	20,702	5,900	3,830	
9	600	"	3,640	4,740	29,931	9,260	8,260	8,210
10	600	"	3,640	4,740	27,617	8,420	7,980	7,610
11	620	"	3,600	4,720	35,388	11.660	9,790	10,260
12	620	"	3,600	4,720	32,764	10,190	9,730	9,120
13	720	"	3,560	4,780	42,709	15,170	12,530	13,440
14	720	"	3,560	4,780	41,883	17,880	12,260	15,150
15	720	"	3,560	4,780	40,690	13,220	12,710	11,820
16	800	"	3,500	4,800	48,892	22,580	14,290	18,950
17	800	"	3,500	4,800	46,454	18,040	13,990	16,040
18	880	"	3,400	4,780	54,767	25,820	15,930	22,290
19	880	"	3,400	4,780	50,295	19,400	14,050	16,320
20	940	"	3,300	4,740	62,038	30,890	18,290	26,010
21	940	"	3,300	4,740	59,254	23,080	16,520	19,580
22	1,000	"	3,200	4,700	70,128	37,050	20,830	30,180
23	1,000	"	3,200	4,700	66,779	27,930	20,460	23,560
24	1,050	"	3,150	4,700	78,156	40,820	23,210	33,020
25	1,050	"	3,150	4,700	76,323	32,640	23,260	27,360
26	1,100	"	3,100	4,700	86,632	48,090	27,060	39,140
27	1,100	"	3,100	4,700	86,053	39,630	27,140	33,390

Strains given are for one truss, and in 1,000 pounds.
Sections given are for one truss (rods assumed not upset).
Loads in above table are for two trusses.
Strains are those due to dead load + maximum from moving load.
Assumed live loads are intended to fully equal (in strains produced) those given in diagram below.
Load on a floor beam, 14,000 pounds, on a panel length of chord as a beam; 36,000 pounds on an axle.
Wrought iron in tension, 10,000 pounds (net section at root of thread) per square inch.
Wood (in compression only) 1-6 to 1-8 of breaking load by Smith's formula.
Wood (in tension only) usually 800 pounds to 1,000 pounds, (500 pounds to 800 pounds in shortest span), per square inch; and as packed beam maximum section (net section) 800 to 1,000 pounds.

LATERAL SYSTEMS.

DECK SPANS—A uniform load of 150 pounds per foot (each system), ⅓ of it at feet of rods.
A moving load of 150 pounds per foot (each system), all of it at feet of rods.
Sway braces at each panel assumed to equalize the strains so that each system is the same (except end rods).
THROUGH SPANS—A uniform load of 150 pounds to 200 pounds per foot (each system). A moving load of 300 pounds per foot (lower system).
Iron 13,000 to 15,000 pounds per square inch net. Timber 1-4 to 1-5 breaking load.

The spans included in the diagrams are:

30 ft. half-through and deck.
40 " " " "
50 " " " "
60 " " " "
70 " " " "
80 " " " "
90 " through, half-through and deck.

100 ft. through, and deck.
110 " " "
120 " " "
130 " " "
140 " " "
150 " " "

This includes in all 27 different trusses, covering the entire range usually required for wooden trusses, spans exceeding 150 feet being rarely built of wood.

In a letter transmitting these strain sheets, Mr. W. A. DOANE, M. Am. Soc. C. E., gives the following further details:

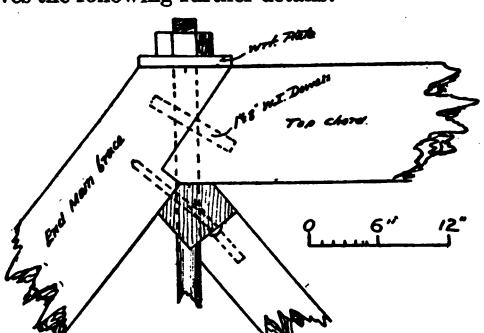


Fig. 1. Top Chord End Joints for Howe Truss Spans up to 90 ft.

" Howe truss bridges, not yet having had their day—at least in the South and West—I send you a set of strain sheets from 30 feet to 150 feet spans, designed for heavy traffic. They require little explanation beyond that given by the attached notes and table of data.

It is intended to use upset rods for all spans above 60 or 70 feet, although diameters given are those required to give the necessary area at root of thread. The table of data gives approximate weights in each case. As will be seen, from 1,000 to 9,000 pounds of iron per span are saved by upsetting the ends of rods.

It is believed that some details of construction have been improved in these designs.

" Fig. 1 (enlarged scale) shows the general style of joints at junction of top chord with end mains for all through spans up to 90 feet.

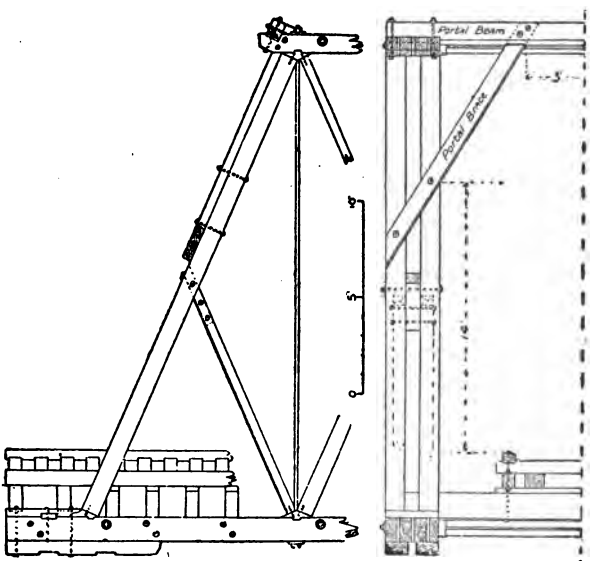


Fig. 3. Portal Bracing for Howe Truss Through Spans of 90 ft. and over.

"Fig. 3 shows general style of portal bracing, etc., for through spans over 90 feet, these having a system of top lateral bracing. In no case are vertical end posts used to meet a useless prolongation of top chord in through spans.

"For spans of 100 feet and over, the usual style of cast brace blocks is followed, having tubes slightly let in to chord timbers and long enough to reach the opposite face of chord and receive the strain transmitted from the rods through the plates. These latter are in all cases made unusually wide, however.

"In spans less than 100 feet the tubes are dispensed with, and a block of the style shown in Fig. 2 is used, having a full bearing on the chord as well as for the braces, while the radial longitudinal ribs greatly increase the strength. The open ends are not objectionable."

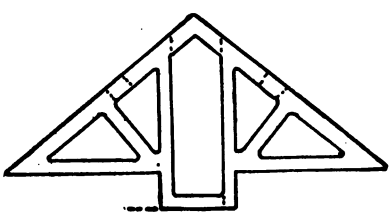


Fig. 2. Cast Brace-Block for Howe Truss Spans under 100 ft.

It was not practicable to reproduce the sheet of diagrams for this book. The reader who wishes to post himself on the best practice in Howe truss construction can consult the number of the journal in which the diagrams are published.

Table for Computing Right of Way Areas.—Width 100 Ft.

Stations.	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9		
0...	0.000	0.023	0.046	0.069	0.092	0.115	0.138	0.161	0.184	0.207		Feet.
1...	0.230	0.253	0.276	0.299	0.322	0.345	0.368	0.391	0.414	0.437	.01	.0023
2..	0.460	0.483	0.506	0.529	0.552	0.575	0.598	0.621	0.644	0.667	.02	.0046
3...	0.690	0.713	0.736	0.759	0 782	0.805	0.828	0.851	0.874	0.897	.03	.0069
4...	0.920	0.943	0 966	0.989	1 012	1.035	1.058	1.081	1.104	1.127	.04	.0092
5...	1.150	1.173	1.196	1.219	1.242	1 265	1.288	1.311	1.334	1.357	.05	.0115
6...	1.380	1 403	1.426	1.449	1.472	1.495	1.518	1.541	1.564	1.587	.06	.0138
7...	1.610	1.633	1.656	1.679	1.702	1.725	1.748	1.771	1.794	1.817	.07	.0161
8...	1.840	1.863	1.886	1.909	1.932	1.955	1.978	2.001	2.024	2.047	.08	.0184
9...	2.070	2.093	2.116	2.139	2.162	2.185	2.208	2.231	2.254	2.277	.09	.0207
10...	2.300	2.323	2.346	2.369	2.392	2.415	2.438	2.461	2.484	2.507	.10	.0230
11...	2.530	2.553	2.576	2.599	2.622	2.645	2.668	2.691	2.714	2.737	....	.....
12...	2.760	2.783	2.806	2.829	2.852	2.875	2.898	2.921	2.944	2.967	..	.....
13...	2.990	3.013	3.036	3.059	3.082	3.105	3 128	3.151	3.174	3.197	....	.....
14...	3.220	3.243	3.266	3.289	3.312	3.335	3.358	3.381	3.404	3.427	....	.....
15...	3.450	3.473	3.496	3 519	3.542	3.565	3.588	3.611	3.634	3.657	....	.....
16..	3.680	3.703	3.726	3.749	3.772	3.795	3.818	3.841	3.864	3.887	....	.....
17 ..	3.910	3.933	3.956	3.979	4.002	4.025	4.048	4.071	4.094	4.117	....	.....
18...	4.140	4.163	4.186	4.209	4.232	4.255	4.278	4.301	4.334	4.347	....	.....
19...	4.370	4 393	4.416	4.439	4.462	4.485	4.508	4.531	4.554	4.577	....	.....
20...	4.600	4.623	4.646	4.669	4.692	4.715	4.738	4.761	4.784	4.807	....	.....
21...	4.830	4.853	4.876	4.899	4.922	4.945	4.968	4.991	5.014	5.037	....	.....
22...	5.060	5.083	5.106	5.129	5.152	5.175	5.198	5.221	5.244	5.267	....	.....
23...	5.290	5.313	5.336	5.359	5.382	5.405	5.428	5.451	5.474	5.497	....	.....
24...	5.520	5.543	5.566	5.589	5.612	5.635	5.658	5.681	5.704	5.727	....	.....
25...	5.750	5.773	5.796	5.819	5.842	5 865	5.888	5.911	5.934	5 957	....	.....
26...	5.980	6.003	6.026	6.049	6.072	6.095	6.118	6.141	6.164	6.187	....	.. ...
27...	6.210	6.233	6.256	6.279	6.302	6.325	6.348	6.371	6.394	6.417	....	.....
28...	6.440	6.463	6.486	6.509	6.532	6.555	6.578	6.601	6.624	6.647	....	.....
29...	6.670	6.693	6.716	6.739	6.762	6.785	6.808	6.831	6.854	6.877	....	.....
30...	6.900	6.923	6.946	6.969	6.992	7.015	7.038	7.061	7.084	7.107	....	.....

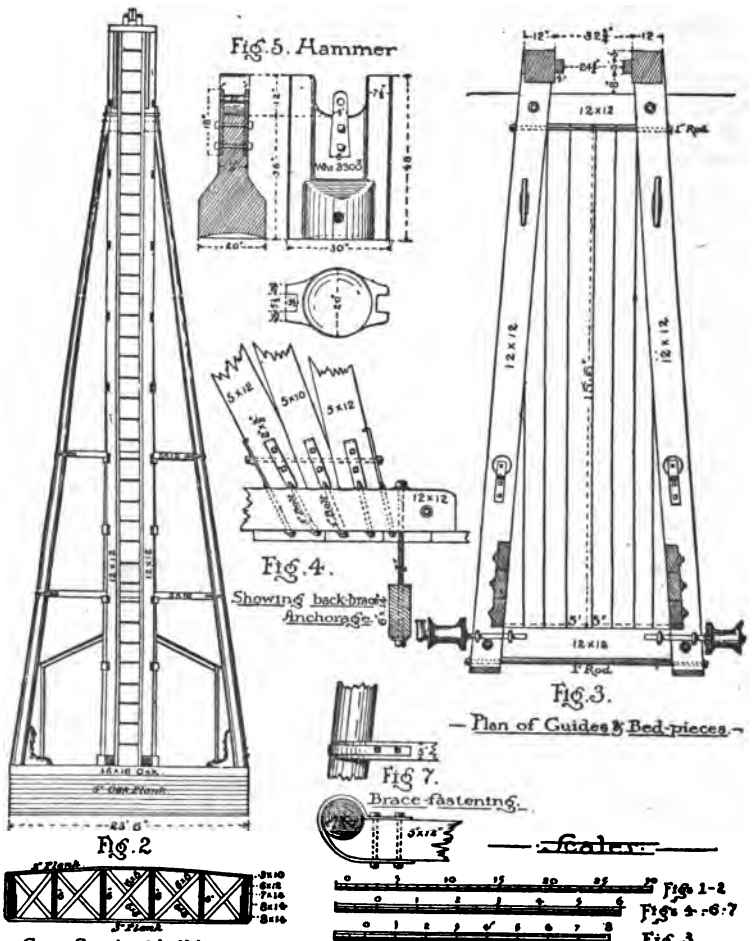
Having the distance between the boundaries of the tract through which the line passes, find the number of stations in the left hand column and in the column of tenths under .0 to 0.9 will be found the acres required, if the plus is an even 10 ft. If the plus contains odd feet the correction to be added is found in the column of feet.

Engineering News.

E. A. D. PARKER,
Kearney, Neb.

PILE DRIVING MACHINE.

The machine illustrated is one of the very latest in model, and the heaviest in New York harbor.



Details of Pile Driving Machine.

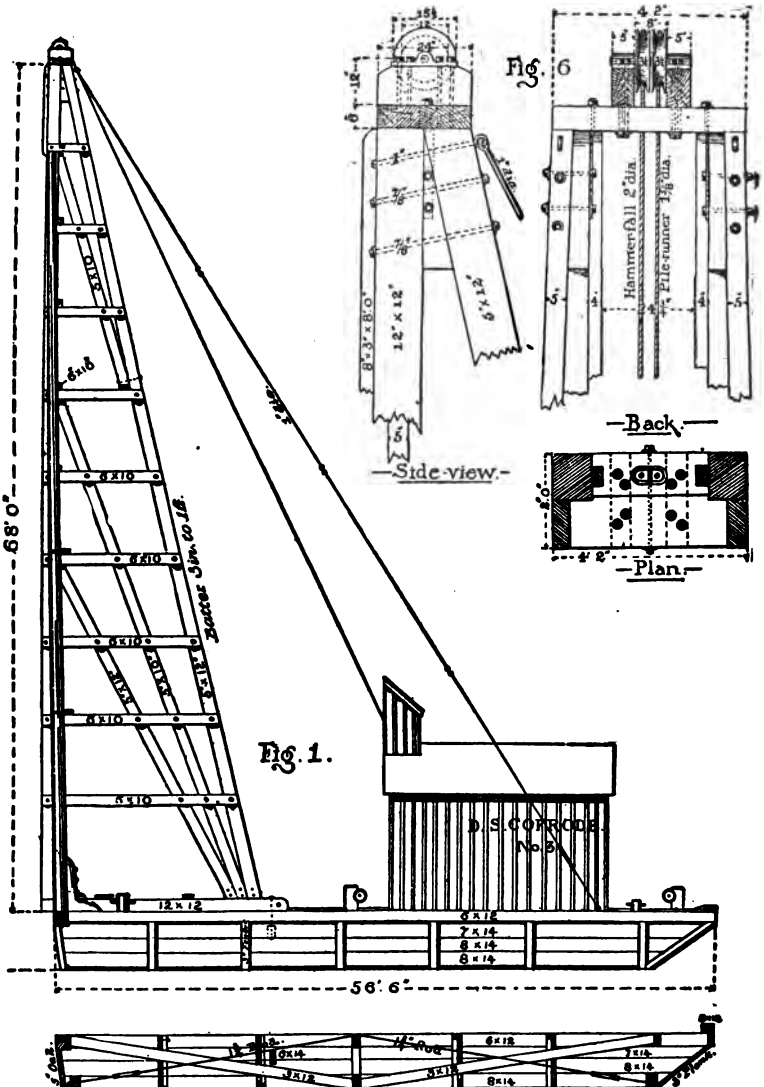
The hull is 56 ft. 6 ins. long and 23 ft. 6 ins. wide over all; each of the sides of the hull is made of four pieces of yellow pine, the two lower each 8 × 14 in., the third 7 × 14 in., the top piece 6 × 14 in., all securely tied by through bolts; the bow planking is oak, 5 ins. thick; the bottom and end plank yellow pine, 3 ins. thick. The bow is further strengthened by a 16 × 16 in. cross timber at top, and at the stern is an 8 × 12-in. cross timber of yellow pine. Oak is used on the bow as being better adapted to stand the constant wear of the piles hauled against it, and to prevent knots or inequalities on the piles interfering with their position under the hammer; the bow planking overhangs 6 ins. in its total height.

The chief end in the design of a hull for a floating pile driver is to obtain longitudinal stiffness, so that the strains between the bow and engine may be properly distributed. To this end our hull is strengthened lengthwise by four wooden bulkheads or kelsons, each 6 ins. thick (Fig. 2) and braced laterally by four sets of X braces of 6 × 6 timber. The hull is further braced in the center by two 3 × 12 in. Y. P. braces, and tie rods or "hog chains" of iron, 1¼ ins. in diameter. Wale pieces and fender plank 3 ins. thick protect the outside of the hull against chafing; the deck has a "crown" of about 6 ins. in its total width.

The hammer-guides are made of two pieces of 12×12 Y. P. 67 feet long from out to out with inside guides of 5×4 in. stuff protected by plate iron ½ ins. thick; ⅝-in. bolts with countersunk heads fasten the inner guides to the main sticks and at the same time secure the iron work to the same. The bottoms of the main guides are connected with the 12×12 bed pieces, shown in Fig. 3, by two timber knees, and are tied at top by the cap shown in Fig. 6.

The dimensions and general arrangement of the back-bracing is fully shown in Figs. 1 and 3; the bolts used in this portion of the frame work are ⅞ in. diameter. The side braces are round timbers 16-ins. diameter at the butt, and they are anchored to the hull by two heavy timber knees to each. The bed pieces, as shown at Fig. 3, are fastened down to the hull by four bolts each, 1 in. in diameter, the forward bolts passing through the 16×16-in. oak piece on bow, and the after-bolts passing into a cross timber 6×14 ins., as shown at Fig. 4. The foot of the back-bracing is secured to the bed timbers by one 1 in. strap-bolt in each timber, the strap portion of bolt being 2×½ in. in section. A ⅞-in. through-bolt ties the three braces together.

The iron stay-rods running from head of guides to after part of hull are two in number, and are each 1 in. in diameter.



Long. Sec. showing internal bracing.

Pile Driving Machine.

The hoisting sheaves on top are two in number, placed side by side. They are 12 ins. in working diameter, 1¼ ins. from out to out, and 3¼ ins. wide; and the pin passing through them is 2¼ ins. diameter at the sheaves, and 2 ins. diameter in the boxes. Experience teaches that these proportions are none too great to stand the severe work frequently put upon it in hoisting heavy weights and tearing out timber. The fall rope attached to the hammer is 2 ins. in diameter, and the "runner" used in hoisting up piles is 1¼ ins. diameter.

The hoisting engine is a double-drummed Mundy engine of a nominal 25 horse power.

Fig. 5 shows the hammer used with this machine. The drawing is sufficient to show its general design. The weight is 3,300 lbs.

Fig. 7 shows the method of attaching the two 5 × 12 in. horizontal braces to the round side braces, as further shown in Fig. 2.

METRIC RAILWAY CURVES.

[From Engineering News, Oct. 13, 1883.]

Several inquiries have appeared from time to time in ENGINEERING NEWS for a metric table of railway curves. We to-day present one prepared by an engineer who, after practicing the American method of laying out curves in the United States, has been for two years occupied in railroad surveying with the metric system in Mexico.

The table is explained by the headings of the columns. Curves are designated (as in the first column) by the angle which, according to the American system, has to be turned off repeatedly at a point on the circumference, and is subtended by successive equal chords. This angle is called by Trautwine and Shunk the "tangential" angle; by Henck and Searles the "deflection" angle. In the first article of the appendix to his revised edition, Prof. Henck suggests the use of this angle for designating curves run by the metric system. An obvious advantage thus gained is that the angle to be measured in staking out a curve in a field is simply the angle named in speaking of the curve. The equal chords successively measured according to the metric system should be 20 meters in length, as was abundantly enforced by numerous writers who discussed the point in ENGINEERING NEWS a year and a half ago. As to the adaptability of that length to railroad engineering, it may be noticed that in the first example of staking out a curve given in Shunk's "Field Engineer," the length of chord is taken to be 20.12 m., which he calls 66 feet. The stakes, set at successive 20-meter intervals, are to be marked with the successive *even* numbers, 2, 4, 6, 8, etc., so as to constitute the dekameter the unit of stake numbering. Each stake is thus designated by its distance in dekameters from the zero point, and each kilometer stake is marked by an exact hundred. The angle by which the curve changes its direction per unit of length as thus marked is, therefore, one-half of its change of direction between the extremities of the 20-meter chord; that is, it is exactly the "20-meter chord" angle used to stake it out and to designate it; and the total change of direction made by any length of the curve is simply the product of this angle multiplied by the difference

in the numbers of the stakes at its beginning and end, just as in the present practice in the United States.

For convenience in staking fractional parts of the 20-meter chain, the second column of the table is given, showing the number of minutes to be turned off with the transit per meter, being simply one-twentieth of the angle in the first column. Here a slight advantage over the 100-ft. chord is seen, because 60 bears a simpler relation to 20 than to 100.

The column of radii presents a simplicity superior to the 100-ft. system, in that the metric radius is just 10 times the co-secant of the angle in the first column, and can therefore be taken directly from a trigonometrical table by altering the decimal point, or in the case of the logarithm, the characteristic. The computation in the present United States practice is a little more complicated. The difference thereby produced in the figures may be seen by comparing the columns of 20-meter chord angle and radius with the columns of degree of curve and radius in the field-books commonly used in this country. The metric radii, instead of being figured exactly one-tenth of the expression in feet corresponding to the same angle, have slightly larger decimals. The discrepancy is so small, however, that for the greater part of railroad work the old tables might be used with the metric system, by taking the old degrees for the 20-meter chord angles and dividing all the old radii by 10, that is, merely changing the decimal point one place. It is different with the figures for deflection distances and ordinates, which, in the metric table, are almost exactly four-tenths of what they are in the old tables for the same angle in first column.

The precise length of the curve, in contradistinction to that of the chords by which it is staked out, is seldom required. The last column in the table is inserted chiefly with a view to exhibiting the percentage to be added to such a chord to get the length of arc it subtends. This percentage is clearly seen when we move the decimal point of the last column one place to the left; and it may be made useful in connection with such tables as are given at the end of Shunk's "Field Engineer" and of the revised edition of Henck's "Field Book." For example, those tables give, among other very useful data, the distance from the intersection point to either extremity of a one-degree curve whose total length varies between 0° and 90°. Mr. Shunk calls this the "apex distance;" Prof. Henck, the "tangent." For a curve 90° in length, Mr. Shunk's table gives 5730 ft. Prof. Henck's, 5729.7 ft., the same, of course, as the radius. Either of these divided by 10 can be used in practice for the metric 1° curve, whose

20 m. Chord Angle.	Minutes to be laid off per meter.	Radius in meters	Logarithm of radius.	Deflection. From tangent.	Deflection. From chord.	Middle ordinate at distance from end-chord. Of 10 m.	Quarter point ordinate at distance from end-chord. Of 5 m.	Length in meters of Arc of designated number of degrees.
0° 10′	0½′	3437.75	3.5362745	.058	.116	.015	.011	10.0000
20′	1′	1718.88	3.2352463	.116	.233	.029	.022	10.0001
30′	1½′	1145.93	3.0591581	.175	.349	.044	.033	10.0001
40′	2′	859.46	2.9342237	.233	.465	.058	.044	10.0002
50′	2½′	687.57	2.8373192	.291	.582	.073	.055	10.0004
1° 0′	3′	572.99	2.7581447	.349	.698	.087	.065	10.0005
10′	3½′	491.14	2.6912059	.407	.814	.102	.076	10.0007
20′	4′	429.76	2.6332231	.465	.931	.116	.087	10.0009
30′	4½′	382.02	2.5820810	.524	1.047	.131	.098	10.0011
40′	5′	343.82	2.5363351	.582	1.163	.145	.109	10.0014
50′	5½′	312.58	2.4949553	.640	1.280	.160	.120	10.0017
2° 0′	6′	286.54	2.4571808	.698	1.396	.175	.131	10.0020
10′	6½′	264.51	2.4224340	.756	1.512	.189	.142	10.0024
20′	7′	245.62	2.3902659	.814	1.629	.204	.153	10.0028
30′	7½′	229.26	2.3603204	.873	1.745	.218	.164	10.0032
40′	8′	214.94	2.3323107	.931	1.861	.233	.175	10.0036
50′	8½′	202.30	2.3060020	.989	1.977	.247	.186	10.0041
3° 0′	9′	191.07	2.2811998	1.047	2.093	.262	.196	10.0046
10′	9½′	181.03	2.2577414	1.105	2.210	.276	.207	10.0051
20′	10′	171.98	2.2354889	1.163	2.326	.291	.218	10.0056
30′	10½′	163.80	2.2143247	1.222	2.442	.306	.229	10.0062
40′	11′	156.37	2.1941477	1.280	2.558	.320	.240	10.0068
50′	11½′	149.58	2.1748701	1.338	2.674	.335	.251	10.0075
4° 0′	12′	143.36	2.1564155	1.396	2.790	.349	.262	10.0081
10′	12½′	137.63	2.1387167	1.454	2.906	.364	.273	10.0088
20′	13′	132.35	2.1217146	1.512	3.022	.378	.284	10.0095
30′	13½′	127.45	2.1053567	1.570	3.138	.393	.295	10.0103
40′	14′	122.91	2.0895961	1.629	3.254	.407	.306	10.0111
50′	14½′	118.68	2.0743911	1.687	3.370	.422	.317	10.0119
5° 0′	15′	114.74	2.0597040	1.745	3.486	.437	.328	10.0127
20′	16′	107.58	2.0317513	1.861	3.718	.466	.349	10.0145
40′	17′	101.28	2.0055032	1.977	3.950	.495	.371	10.0163
6° 0′	18′	95.67	1.9807654	2.093	4.181	.524	.393	10.0183
20′	19′	90.65	1.9573751	2.210	4.413	.553	.415	10.0204
40′	20′	86.14	1.9351943	2.326	4.644	.582	.437	10.0226
7° 0′	21′	82.06	1.9141055	2.442	4.875	.612	.459	10.0249
20′	22′	78.34	1.8940076	2.558	5.106	.641	.481	10.0274
40′	23′	74.96	1.8748128	2.674	5.336	.670	.503	10.0299
8° 0′	24′	71.85	1.8564447	2.790	5.567	.699	.525	10.0326
20′	25′	69.00	1.8388361	2.906	5.797	.729	.547	10.0353
40′	26′	66.36	1.8219279	3.022	6.027	.758	.569	10.0382
9° 0′	27′	63.92	1.8056676	3.138	6.257	.787	.591	10.0412
20′	28′	61.66	1.7900083	3.254	6.487	.816	.613	10.0444
40′	29′	59.55	1.7749082	3.370	6.717	.846	.635	10.0476
10° 0′	30′	57.59	1.7603298	3.486	6.946	.875	.657	10.0510

radius is 572.99. (It would be still better in using the metric system to have a new table calculated expressly for radius 572.958.) To get with very close approximation the corresponding dimensions for any other curve we divide by the degree designating the curve. Hence, for a 90° length of a metric 10° curve we should get a tangent or apex distance of 57.30 m. In the case of so sharp a curve the question arises whether this is sufficiently accurate for our purpose, and this question is answered by reference to the last column in the metric table. After moving the decimal point as above directed, we find 1.0051 for the 10° curve, showing that our 57.30 is in error by one-half of one per cent. To get exactly the distance required, multiply 5730 by 1.005, and we get 57.59, just as given in the metric table for the radius of the 10° curve. The same percentage correction is applicable to the other tabulated data as well as to the tangent or apex distance.

In computations like that discussed in the preceding paragraph, the 20-meter chord has the advantage over that of 100 ft. that it is a shorter length, and consequently the arc it subtends in any circle differs by a smaller percentage from the chord. Hence, the tabulated data above mentioned can be applied without requiring correction to a larger range of metric curves than of the curves used in the American foot practice. For example, observe that in the curves of 86.14 and 90.65 meters radius the percentage is less than one-quarter of one per cent. Between the two lies the 20° curve, as given in the American tables, with a radius of 287.9 ft., in which the 100-ft. chord subtends an arc of 100.5 ft., showing a percentage of one-half of one per cent. Accordingly, if we start 5,730 ft., the tabulated tangent or apex distance above cited for 90° length of an American 1° curve, and take one-twentieth of it for the corresponding dimension of the circle of 287.9 ft., radius, we have 286.5 ft., and must add 1.4 ft. to get the correct value equal to radius. On the other hand, suppose we had started with 573 meters as the tangent or apex distance in the metric 1° curve, to get the corresponding dimension of the circle of 86.14 meters radius observe that that circle is designated by the 20 m. chord angle of 6⅔°; three-twentieths of 573 m. is 85.95 m., and to get the correct value equal to radius we must add 0.19 m., which is lees than half of 1.4 ft., and less than one quarter of one per cent.

Engineers accustomed to thinking of curves by their American designations may find it convenient in making mental comparisons to bear in mind that if any curve has its 20-m. chord angle multiplied by 3, the product is nearly the "degree" used to designate the curve in this country;

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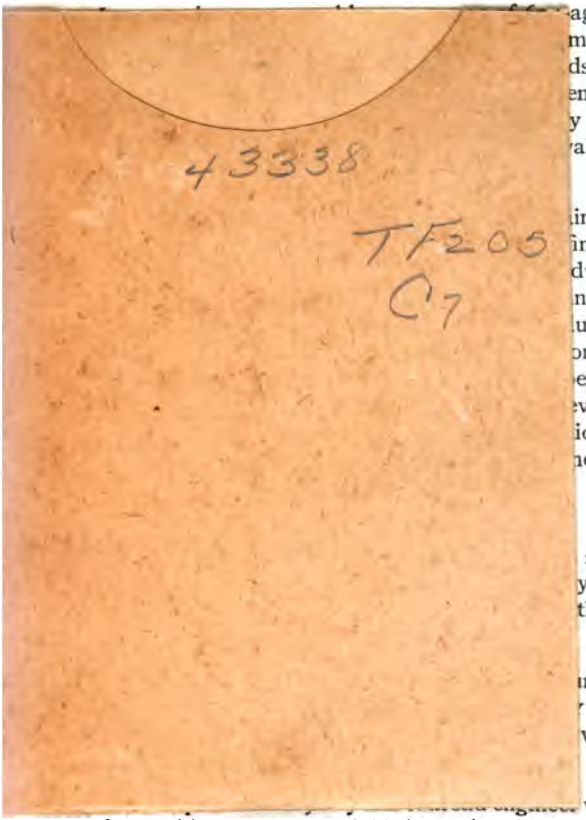

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